

PROCEEDINGS 35TH YEAR

JOURNAL
OF THE
AMERICAN WATER WORKS
ASSOCIATION

VOLUME II
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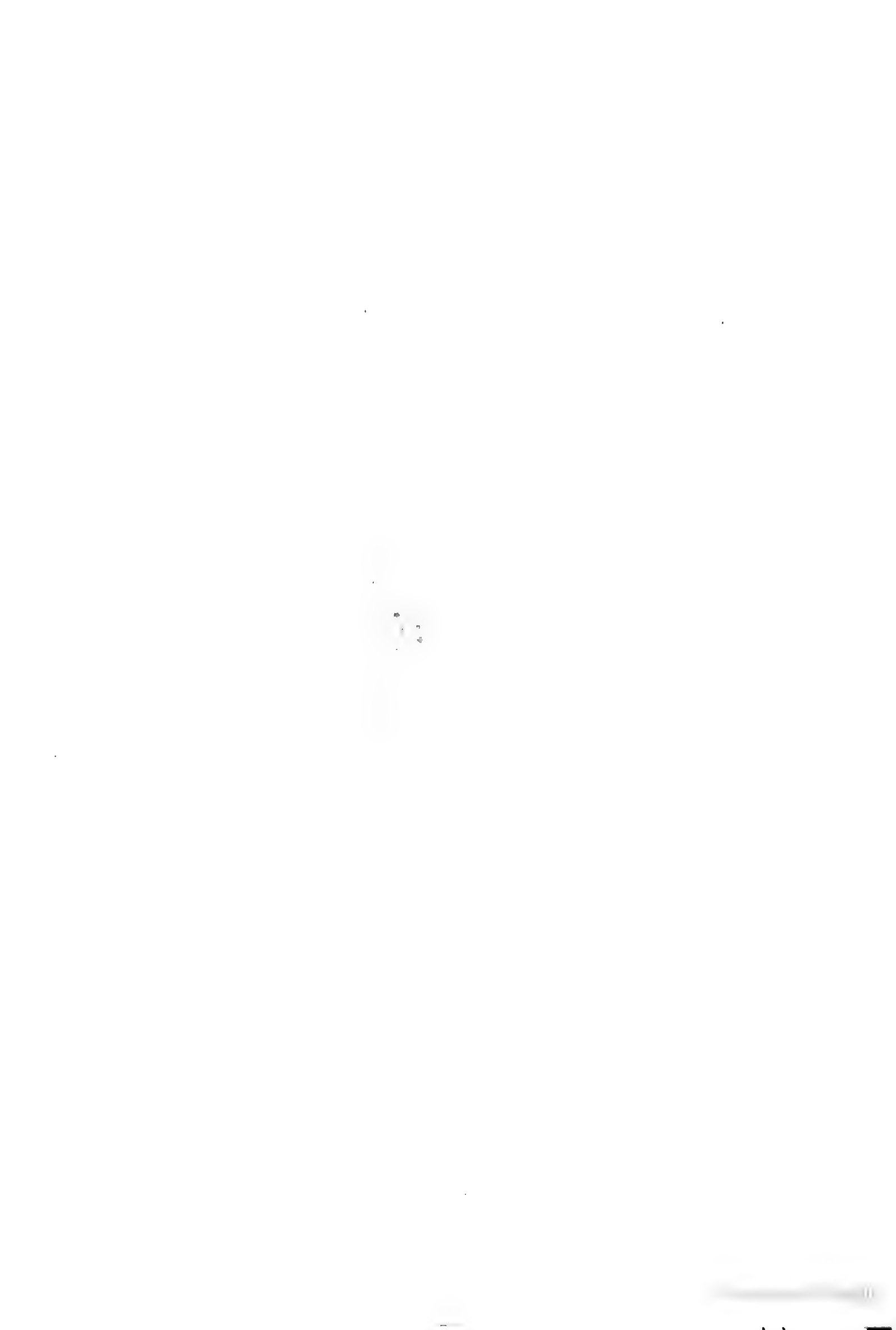
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AMERICAN WATER WORKS ASSOCIATION

THE 1915 CONVENTION

The 1915 Convention will be held at Cincinnati, Ohio, May 10-14, with headquarters at the Hotel Gibson, where very complete arrangements have been made, both for the business sessions and for exhibits of water works appliances.

The papers printed in this JOURNAL will be brought up for discussion, and as they are printed in advance of the convention will be read there by title or brief summary. It is hoped that the authors will in all cases be present to take part in the discussion on their papers and to answer any questions that may be asked concerning the papers. Members who cannot attend the convention are urged to send written discussion on papers printed in this JOURNAL.

Other papers have been promised for the convention, and will be read and discussed during the convention.

THE SECTIONS

New York Section

The third meeting of the New York Section was held at the Manhattan Hotel, December 3, 1915. Seventy-nine members and guests were present. In the absence of the President of the section, Mr. Morris R. Sherrerd, Mr. Allen Hazen, Secretary of the section presided, and in opening the meeting announced that the proposed constitution of the New York Section presented to the Executive Committee of the American Water Works Association had not as yet been acted upon. (Note: The Executive Committee have since the meeting approved the constitution as presented.)

Luncheon was served at 12.30, and at the conclusion of the luncheon the order of business was taken up and papers were presented by Messrs. William W. Frush, deputy chief engineer department of water supply, gas and electricity of the city of New York, and D. F. Fulton, city engineer, Yonkers, New York. Mr. Frush's paper was on the Maintenance of the Water Supply Distribution of New York City; Mr. Fulton's paper The Yonkers Water Supply and its Future Development. Both papers were illustrated with lantern slides.

Illinois Section

A special meeting of the Illinois Water Supply Association was held at Hotel Sherman, Chicago, November 11, 1914. The special business for which the meeting was called was to take the necessary steps to become a section of the American Water Works Association, in accordance with a ballot of the Association in which a large majority favored the formation of a section.

The members assembled at the hotel, and at ten o'clock left in automobiles to visit the Chicago Avenue and Montrose Avenue pumping stations of the Chicago Water Department. At one o'clock luncheon was served at the Edgewater Golf Club, after which the members visited the New Evanston filter plant, followed by a visit to the Wilmette pumping station of the Chicago drainage district, the Patten gymnasium of the Northwestern University, and the Medinah Shrine, the large auditorium of the Chicago Shriners. Dinner was served at the Hotel Sherman. At eight o'clock the business meeting was called to order by President H. M. Ely. President Ely reported the vote of the members concerning affiliation with the American Water Works Association as a section. One hundred and ten votes were cast for, and eleven against the proposed affiliation. The Executive Committee had concluded that they were justified in taking the necessary steps to form a section, and had prepared a constitution to be submitted at the meeting. This constitution was adopted as a whole, and provisional officers were elected to serve until permanent officers should be elected in accordance with the provisions of the constitution.

The Nominating Committee, consisting of Mr. Dabney H. Maury, Chairman, Mr. A. N. Talbot and Mr. F. J. Bradley, reported the following nominations: H. M. Ely, Chairman; John Ericson, Vice-Chairman; H. E. Keeler, Treasurer; Trustees, W. W. DeBerard, E. MacDonald, W. J. Spaulding. The report of the Committee was accepted, and the Secretary instructed to cast the ballot of the Association for the nominees. It was voted that the Executive Committee of the American Water Works Association be asked to consider as charter members all members of the Illinois Water Supply Association residing in Illinois who should qualify for membership prior to the next meeting of the Illinois Water Supply Association, to be held in March.

Votes of thanks were extended to the Hotel Sherman for the

very satisfactory arrangements for the meeting, and to the Chicago Local Committee, consisting of Mr. H. E. Keeler, Chairman, and Messrs. J. W. Alvord, F. J. Bradley, H. F. Brown, W. W. DeBerard, J. E. Ericson, D. K. French, S. C. Haddon, J. L. Hecht, C. A. Jennings, D. H. Maury, Langdon Pearse, for the splendid entertainment which was carried out under their direction.

A paper, The Evanston Filtration Plant, illustrated by lantern slides, was delivered by Mr. Langdon Pearse; also a paper, Observations of Some European Water Purification and Sewage Disposal Plants, illustrated by lantern slides, was given by Mr. Edward Bartow. By request Mr. Bartow gave a brief account of his experiences in Europe after the outbreak of the war.

Adjourned.

The members of the Executive Committee who were present met and appointed Mr. Edward Bartow Secretary of the Section.

CONSTITUTION AND BY-LAWS OF THE ILLINOIS SECTION OF THE AMERICAN WATER WORKS ASSOCIATION

ARTICLE I

This Association shall be known as the "Illinois Section of the American Water Works Association," succeeding the "Illinois Water Supply Association."

ARTICLE II

The object of this organization shall be the same as that of the American Water Works Association, namely, "The advancement of knowledge of the design, construction, operation and management of water works, and the encouragement, by social intercourse among its members, of a friendly exchange of information and experience."

ARTICLE III

The headquarters of this Section shall be the University of Illinois, Urbana, Illinois.

ARTICLE IV

The membership shall consist of the members of the American Water Works Association residing in the state of Illinois.

ARTICLE V

SECTION 1. The officers of the Section shall be Chairman, Vice-Chairman, Secretary, Treasurer, and three Trustees, who shall perform the duties usually incumbent upon such officers. These officers shall constitute an Executive Committee. They shall hold office for one year, Trustees three years, or until their successors are chosen. Vacancies in the list of officers may be filled by the Executive Committee.

SECTION 2. At least thirty days before each annual meeting of the Section, the Secretary shall mail to each active, honorary, or corporate member, a blank upon which the member may express his choice for Chairman, Vice-Chairman, Treasurer and one Trustee. The Secretary in conjunction with two other members appointed by the Chairman shall count all nominating ballots before the date for the annual meeting. The three members who shall have received the greatest number of nominating ballots for each office shall be voted on by ballot by the members present at the annual meeting. The Secretary shall be appointed by the Executive Committee.

SECTION 3. The Treasurer shall submit all bills to the Chairman of the section before payment, and shall perform the duties required under Section IV, Article X, of the Constitution of the American Water Works Association.

SECTION 4. Twenty members shall constitute a quorum for the transaction of business.

SECTION 5. At the regular meetings of the section, the business shall be conducted in the following order:

Reading of Minutes, Reports of Officers, Reports of Committees, Miscellaneous business, Announcements, Reading of papers and discussions, Adjournment.

ARTICLE VI

SECTION 1. The meetings shall be held annually at such time as shall be ordered by the Executive Committee. The place of meeting shall be the University of Illinois, Urbana-Champaign, but the Executive Committee shall have power to change the place of meeting if, in their judgment, it seems desirable to do so.

SECTION 2. Special meetings may be called by the Executive Committee, or upon written request of twenty-five members in

good standing. In case of such special meetings the object shall be definitely stated and no other business shall be transacted.

ARTICLE VII

No rules or by-laws of this Section shall be inconsistent with the Constitution and By-Laws of the American Water Works Association.

ARTICLE VIII

The Constitution and By-Laws may be amended by two-thirds vote of those present and entitled to vote at any regular meeting of the Section. Such amendment shall be in effect after approval by the Executive Committee of the American Water Works Association.

JOURNAL
OF THE
AMERICAN WATER WORKS ASSOCIATION

The Association is not responsible, as a body, for the facts
and opinions advanced in any of the papers or discussions
published in its proceedings.

VOL. 2

MARCH 1915

No. 1

THE YONKERS WATER SUPPLY AND ITS FUTURE
DEVELOPMENT

BY D. F. FULTON*

The city of Yonkers, the sixth city in respect to population, of the state of New York, adjoins New York City on its northerly line. It extends from the Hudson River, on which it has a frontage of about four and one-half miles, easterly to the Bronx River and occupies the southwesterly corner of Westchester County. In common with the remaining portion of the southerly part of the county it felt, during 1910 and 1911, the pinch of poverty, as regards water supply, a condition made acute by the unusual dryness of those years together with the ever increasing demands on the supply due to a rapid growth in population and to the increase in consumption by new or expanding manufacturing industries.

The rainfall records of the Water Bureau, continuous since 1878, with the observing station less than one-half mile from the storage reservoir indicates the rainfall of 1910 to be eighteen inches below the average for thirty-three years and that of 1911 to be eleven inches below the average for thirty-four years.

For some time past, it has been plain to the city authorities that the present supply would soon be insufficient to meet requirements and various measures have been adopted to conserve and augment the supply and to minimize waste. These measures although fairly

*City Engineer, Yonkers, N. Y.

successful were not, nor were they expected to be sufficient to relieve the situation for any length of time and Yonkers now proposes to obtain water to meet estimated demands for a period of from fifteen to twenty years.

Before describing the method by which it is proposed to obtain this increase, a brief historical outline of the origin and growth of the present supply and works will perhaps be interesting.

Topographically, Yonkers is divided into a series of ridges and valleys extending in a generally north and south direction. The northerly part of the city is traversed by three streams, the largest and most westerly of which is the Saw Mill or Nepperhan River which in former years was the source of power for many mills in Yonkers and which when it reaches the center of the city flows westerly into the Hudson River.

Occupying the next valley to the east of the Saw Mill River and separated from it by a high narrow ridge, is the Sprain. East of the Sprain and similarly separated from it, lies the Grassy Sprain. Within the city, however, they meet and flow in a southeasterly direction into the Bronx River.

In 1876 there was constructed what has generally been known as our Grassy Sprain Supply.

A canal, part of the original works, diverts the flowage of the upper Sprain into the Grassy Sprain and this combined catchment area amounts to $4\frac{1}{2}$ square miles.

On the Grassy Sprain a storage reservoir was formed by the construction of an earth dam with flowline at about elevation 118, the capacity of which was 440 million gallons. Water was pumped to the small Lake Avenue Reservoir and from it flowed by gravity into the distributing mains.

About 1885, a tank or tower was constructed near the Lake Avenue reservoir, a pump installed, and the water repumped to the tower. This arrangement with an additional tower and some enlargements constitutes our high service system today.

By 1895, the draught had become so heavy that the supply was somewhat augmented by driving, in the Saw Mill River Valley, some 12 to 15 tubular wells. These wells averaged about 40 feet in depth, tapping the underground water stored in the sandfilled valley. A pumping plant was installed at the site of these wells and the water pumped directly into mains. This station has come to be known as our tubewell or Nepperhan Pumping Station.

At this time Fortfield Distributing Reservoir with flowline at approximately the same elevation as the Lake Avenue Reservoir but with a capacity of 60 million gallons, was constructed.

For some time additional water, amounting to about a million gallons daily, was thus obtained, but the level of the ground water was in the meantime lowered about 28 feet so that by 1903 the amount thus secured had become somewhat less.

In 1903, the supply was further increased by the construction, at the site of the Tube Wells Pumping Station, of two filters of one-half acre each. These filters were of the open, slow sand type and were designed to help out during the summer months.

The filters took the raw water of the Saw Mill River, and for ordinary stages of the river, and in open weather answered their purpose well. They had a combined rated capacity of 3 million gallons daily.

Prior to 1905 and during the spring freshets, considerable water went over the spillway of the Grassy Sprain Dam. In order to avail ourselves of this water the dam was raised about 12 feet, which added height increased the capacity from 440 to 960 million gallons. In 1909 two additional filters of three-quarters of an acre each, of the covered slow sand type and with a combined rated capacity of 4.5 million gallons, were completed.

To permit of the temporary cutting out of a bed, for repairs or cleaning, and in order to secure additional capacity two more filters of the same type and size as those last constructed have just been added to the plant. This brings the total to 4 acres of filters with rated capacity of 12 million gallons daily on the basis of 3 million gallons per acre per day.

In the summer months, when the draught on the supply is heavy, we have an ample capacity in the filtration plant, but unfortunately not sufficient water in the stream.

It is not possible, within reasonable limits of cost, to provide storage at the site of the filters, and as a consequence raw water has to be admitted directly to them. In times of flood, when there is an abundance of water in the Saw Mill River, it unfortunately carries a large amount of matter in suspension. At such times they have to be closed down, and considerable water passes by unused.

These were the conditions with which we faced the unusually dry years of 1910 and 1911.

While Yonkers has been particularly fortunate during the past

four years, the situation at that time was one that required immediate relief. It also emphasized the necessity of developing a plan that would embrace storage sufficient to carry us over at least one dry year, and at the same time to provide a supply ample to meet requirements for a term of years.

In December, 1910, a Joint Water Supply Committee consisting of councilmen and citizens was appointed by the mayor. The committee, after resolving itself into a working body, retained as consulting engineers, to examine into and report on an increased water supply, Messrs. Hazen and Whipple.

As a temporary alleviation of the conditions then existing it was recommended by them, that, inasmuch as all the water reaching the filters was not being used, the rate of filtration be increased to such an extent that practically the entire draught, when possible, should be taken from them.

With the use of hypochlorite in conjunction with the filters it was recommended that the old rate of 3 million gallons per acre, daily, could be safely increased at least 50 per cent, and when this practice became effective the Grassy Sprain Reservoir, being relieved of the draught, began to fill and immediate danger was averted.

In November, 1911, the consulting engineers submitted their report which in substance covered the recommendation that an increased supply of water for the city of Yonkers was to be most economically obtained by developing up to about ultimate capacity, our present sources.

From what has heretofore been said it will be remembered that Yonkers is now obtaining water from three separate sources.

- (1) The Grassy Sprain Supply.
- (2) The Saw Mill River or Filtered Supply.
- (3) The Tube Well Supply.

The amount of water, however, obtained from this last source is very small, almost negligible, so that for all practical purposes our present supply will be considered as from Grassy Sprain and Saw Mill River.

The Grassy Sprain supply, with the raising of the dam in 1905, increasing the storage from 440 to 960 million gallons, saw that supply developed to about its ultimate capacity.

It must be inferred, then, that the development to which reference has heretofore been made means the development of the Saw Mill River supply and in fact that is the substance of the report.

THE REPORT

As an index to the size of works probably required, the population and consumption of the city for the years 1915 to 1930 has been estimated and together with population and consumption for the years 1880 to 1910 is shown in the following table.

<i>Year</i>	<i>Population</i>	<i>Million gallons per day</i>	<i>Gallons per capita</i>
1880.....	18,892	0.86	46
1890.....	32,033	2.17	68
1900.....	47,931	3.25	68
1910.....	79,803	8.20	103
	<i>Estimated</i>		
1915.....	101,000	10.2	100
1920.....	129,000	12.9	100
1925.....	160,000	16.0	100
1930.....	197,000	19.7	100
1935.....	240,000	24.0	100

To many only slightly familiar with conditions in Westchester County it might appear that a supply sufficient to meet the requirement for the year—say—1930 could readily be obtained in the northern part of the county.

A study of the map herewith shown, however, will indicate pretty clearly that New York City has been first on the ground, and when a search is made for a supply of this size it is not quite such a simple problem as at first blush might appear.

In the investigation looking to an outside supply a canvass was made for a considerable distance north of Yonkers of all available catchment areas. Those of Sprout Brook, Oscowanna Brook and Peekskill Creek were considered as affording the most economical sources from which a considerable supply of water could be obtained.

By the construction of dams on Sprout Brook and Peekskill Creek, it was set forth that a supply of 40 million gallons per day could be delivered by gravity at an approximate cost of \$9,500,000 or at a cost of \$234,000 per million gallons daily.

Inasmuch as Peekskill has the first right to the water of Peekskill Creek and Oscowanna Brook, and because of the large amount of capital required for the development, this source was not favorably accepted by the committee.

However, should the future make it desirable for a Metropolitan District for lower Westchester County, this would afford an admirable supply sufficient for a population of 400,000 people.

In general the plans submitted by Hazen and Whipple and adopted by the Joint Water Supply Committee provides for obtaining an increased supply of water from the Saw Mill River. This is to be accomplished by:

(1) Control of flood flows of that river, by enlarging the present Grassy Sprain Storage Reservoir, and the construction of two additional reservoirs.

(2) By the filtration of all water used by the city of Yonkers.

CONTROL OF FLOOD FLOWS OF SAW MILL RIVER

Reference is again called to the map on which is shown a proposed reservoir at East View. Behind this site is a catchment area of about 12 square miles. It is proposed to build here an earth dam, 20 feet wide on top, maximum height 47 feet, 400 feet long at the flowline and provided with gate house and overflow.

With the flowline of this reservoir at elevation 230 and with a capacity of 560 million gallons it is proposed to arrest the floods of the upper area and by the operation of regulating gates this stored water will be passed down the stream to Woodlands Lake, an existing artificial lake with spillway at elevation 155, where an intake is to be constructed.

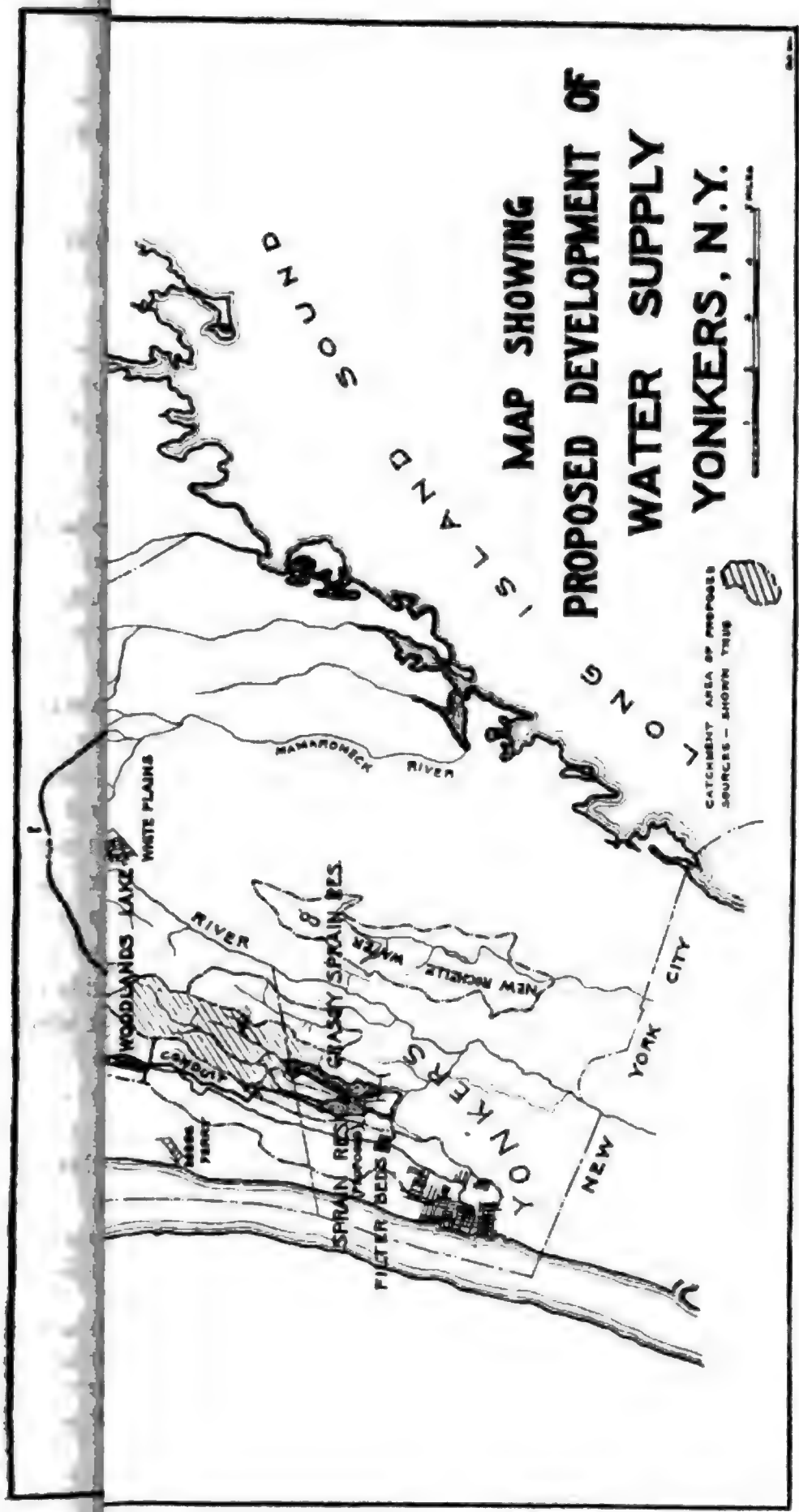
From Woodlands Lake a 72-inch aqueduct and tunnel will conduct the flowage through the ridge into the upper Sprain.

It is to be here noted, that the water of the Saw Mill River, a tributary of the Hudson, is to be diverted to the Sprain, a tributary of the Bronx.

In the lower Sprain Valley it is proposed to form a reservoir by constructing an earth dam 50 feet high and 350 feet long. The reservoir will have a flowline at elevation 147 with the top of the dam at elevation 155.

The Sprain Reservoir, it will be noted from the map, lies directly west of the Grassy Sprain Reservoir, which is to be enlarged by the construction of an earth dam 40 feet higher than the present one, and about 350 feet down stream from it. It will be about 24 feet wide on top and 1070 feet long.

Underlying the present dam, preliminary borings indicate rock at a depth of 90 feet below the brook. The Rock Valley is wide so that there is a large section of material overlying it. This material is largely sand of varying degrees of coarseness, much of it is so coarse as to carry water freely.



**MAP SHOWING
PROPOSED DEVELOPMENT OF
WATER SUPPLY
YONKERS, N.Y.**

CATCHMENT AREA OF PROPOSED
SOURCES - SHOWN TRUE

0 1 2 3 4 5 6 7 8 9 10 MILES

THE
JOURNAL
OF THE
AMERICAN
MEDICAL
ASSOCIATION

For the new dam, it is proposed to provide a cut-off for this underground flowage. It has been suggested that this can be done either by driving steel sheet piling to rock or in the deeper part of the valley by sinking a connected series of caissons and filling them with grout or concrete.

A 6-foot tunnel is to be driven through the ridge between the two reservoirs which will permit filling the Grassy Sprain Reservoir up to elevation 147 by gravity.

The flowline of the enlarged Grassy Sprain Reservoir will be at elevation 170 and to fill the upper 23 feet it is proposed to install a pump at the entrance of the tunnel to be operated by an electric motor, the current for which will be furnished by a generator at the Filter Bed Pumping Station.

Water will be drawn by gravity from either or both of these reservoirs through 48-inch lines to the filter beds. Under ordinary operations the water will be drawn from the Grassy Sprain Reservoir.

It will be noted that by this arrangement no raw water will be taken to the filters but water, only after a considerable period of settling, storage and bleaching both in the Sprain and Grassy Sprain Reservoirs, will be admitted to them.

The filtered water will be pumped directly into the mains and also to the Fortfield Reservoir. This is an open reservoir with a capacity of about 60 million gallons, divided into two equal parts by a masonry wall. It is part of the general scheme to raise and cover this reservoir. Raising has been suggested because it can be done with but little additional cost in connection with the covering.

With the completion of the above outlined works, with a total catchment area of about 24 square miles, it is somewhat conservatively estimated that a supply of about 18 million gallons per day in an ordinary dry year will be obtained. In other years it is expected that from 20 to 22 million gallons daily will be obtained.

With all reservoirs filled we will have 5700 million gallons of water in storage, an amount sufficient for a year's supply at 18 million gallons per day.

This storage will be distributed as follows:

	<i>Gallons</i>
East View Reservoir.....	560,000,000
Sprain Reservoir.....	380,000,000
Grassy Sprain Reservoir.....	4,700,000,000
Fortfield.....	60,000,000
Total.....	5,700,000,000

The estimated cost of the works by which it is proposed to obtain an additional 10 million gallons per day is \$3,073,000 which includes \$1,000,000 for land.

This is at the rate of \$307,000 per million gallons daily, a figure somewhat high, but which is made so, at least in part, by the estimated cost of land to be acquired. Also included in this cost, however difficult to determine, is the value both from a sanitary and commercial view point, of filtering only stored and settled water, as compared with the filtering of raw water, the method in use today.

DISCUSSION

MR. EDWARD L. PEENE: You have heard the paper, as well prepared as could be, on the question of our future water supply, and there seems to be nothing further to add. The speaker simply takes care of the maintenance of our water system, and he has all he can do to take care of that. You will notice that this increased supply is to be furnished at an estimated amount of 18,000,000 gallons per day. The present consumption is about 10,000,000 gallons per day. The population is about 100,000, and this is quite a small amount for such a large city. You know that Yonkers is about 100 per cent metered, and that is why we are able to keep down the amount of water used in the city. Our per capita last year ran close to 98, but, deducting the manufacturing, brings the domestic consumption to 29 gallons per day. Our average use per day for this year, to date, is 7,500,000 gallons, which is due to a completely metered system, and all water pumped being measured by a Venturi meter in place of plunger displacement as heretofore.

MR. ALLEN HAZEN: That is an interesting statement on meters. Can you tell us what per cent of the output is accounted for by your meters?

MR. EDWARD L. PEENE: About 60 to 65 per cent.

MR. JOHN C. TRAUTWINE, JR.: To one who, like the speaker, hails from one of New York's southern suburbs, where the percentage of taps metered approximates zero as a limit, and where the daily per capita draft is something like 180 gallons, or from two

to four times what it has any excuse for being, it is refreshing (if also humiliating) to learn, from Mr. Peene's discussion, that, in the northern suburb of Yonkers, where the percentage of taps metered is 100, the domestic draft is only 29 gallons per capita per day, less than 16 per cent of Philadelphia's, and yet ample; and that the city has been able to get along with a water supply which, under Philadelphia conditions, would have been ridiculously inadequate.

Only today, in this room, a fellow suburbanite, who lives in the fourth story of the Philadelphia Engineers Club, said that, in spite of a pumpage of say 180 gallons per capita per day, he could be sure of getting water from the tap on that floor only when, as happened this morning, he was forced to rise with or before the lark.

For a generation and more those in charge of Philadelphia's water supply have struggled for the introduction of meters, recognizing this as the key, the sufficient key, and the only key, to all our water troubles; and our City Charter expressly places the "Water Works . . . under the direction, control, and administration of the department of public works," expressly forbidding the City Councils to direct or interfere with the exercise of the Department's executive functions, and expressly commanding the City Councils to provide for the proper conduct of the works by the Department.

But, unfortunately, these provisions of the City Charter are a dead letter. The Councils usurp the executive functions of the Department; and, the water meter being practically unknown, and therefore unpopular, in Philadelphia, our city remains in the ranks of the back numbers. It is needless to say that she pays dearly for her backwardness.

Like its predecessors, the present reform administration, in its early days, vigorously espoused the restriction of waste by means of water meters. For the enlightenment of our unhappy people, it set up and maintained, in the City Hall courtyard, an exposition with a screen for lantern slides.

In his report for 1912 Director Cooke said:

We are undoubtedly fortunate in lying at the junction of two such magnificent waterways as the Delaware and Schuylkill . . . but it is not wise to allow this good fortune to be given as an excuse for a profligate waste of water, a waste certainly amounting to one-half of all we use.

(The Director doubtless means one-half of all we consume.)

In his report for 1911 Director Cooke said:

From a study of the results obtained from other cities . . . there is hardly a doubt that, if meters were placed on those properties wherein waste is detected, the consumption would be so reduced that a good supply could be maintained in all sections of the city.

In short, the Department was aware that the use of meters would render the present supply absurdly ample for all the city's needs, for years to come. It is therefore, to put it mildly, disquieting to find the Department now nearly silent on the subject of waste restriction, and to hear Director Cooke publicly quoted as saying that the present supply must speedily be augmented, as favoring the bringing of additional water from distant sources, and as having asked the City Councils for an appropriation of \$15,000 for the employment of experts to advise him in this connection. It is difficult to understand this abrupt and unfortunate change of base; but it may be well to remember the method adopted in the attempted introduction of meters.

Instead of installing meters at the city's discretion, and at the city's expense, the department merely made their use permissive, the consumer paying for the meter, hoping thereby to reduce his water bills. Under this arrangement, of course, meters were installed only, or chiefly, by "those just persons who needed no repentance," persons who wasted little or no water. The result of course was that the city revenue was reduced, without corresponding diminution of waste, and the meter system was brought into undeserved disrepute, to the joy of those who seek to profit by the city's historic plight.

Another fellow suburbanite recently pointed to the present European War as evidence of the alleged fact that the world has too much government, whereas, what the world needs for the prevention of such world nuisances, is a strong world-government, both ready and able to squelch promptly any upstart nation which might elect to derange the world-organization by playing soldier on its own account; and in Philadelphia we need a government which, taking its stand upon the City Charter, will meter the water supply, without a "by your leave" to our ignorant hoi polloi or to its representatives in the municipal legislature.

Mr. Fulton mentioned that, when the city of Yonkers set about utilizing a certain source of water supply in its vicinity, it found that the city of New York had already preempted that supply. Now it is not for us suburbanites to instruct the Metropolis in the

conduct of its affairs, but this statement of Mr. Fulton's indicates the need, in New York State, of some super-municipal administration of water supplies, on the lines of that created by our ever progressive brethren of Massachusetts.

Think of the absurdity of permitting New York City to provide itself with a water supply from within the state, not only without providing for the distribution of that supply among the cities and towns along the line of its conduit, but actually helping itself to a supply which it now appears belongs naturally and properly to one of those towns! What is the state for, if not to prevent such outrages?

As municipal water supply superseded the old-time individual water supply, under which each consumer drew partly from his neighbor's supply, and, incidentally, also from his neighbor's cess-pool; so, the speaker ventures to predict, municipal water supply, a game of "Catch-who-catch-can," will be generally superseded, first by interurban water supply, as in the case of Boston and its surrounding communities, then by the state and interstate administrations, and, eventually and logically, by national, and finally by international water supply administration.

MR. ALLEN HAZEN: Mr. Trautwine's remarks on the Massachusetts control of waters are very interesting. Mr. Cuddeback and some others have been having experiences like that lately, and find that this makes it difficult for cities and towns to get water, which would be easily available if it were not for the state supervision as now conducted.

MR. JOHN C. TRAUTWINE, JR.: Mr. Hazen's statement that state control of waters in Massachusetts sometimes "makes it difficult for cities and towns to get water, which would be easily available if it were not for the state supervision as now conducted," is not at all surprising. It is even probable that the projectors of the New York City supply thought it best for the public welfare that there was no New York State authority to interfere with their designs upon Yonkers and her little ewe lamb.

Doubtless, after the Revolutionary War, when the original thirteen states had formed their "more perfect union," individual states now and then found that, in certain cases, the new Union made it difficult for them to get things which would have been easily

available if it had not been for the Union as then conducted; but probably everyone now recognizes that the benefits accruing to each of our states, by virtue of its present membership in the Union, vastly outweigh any possible inconvenience or loss of prestige or "identity" which that membership may entail.

Under the present "economic" system, which puts its premium upon self-seeking, it is only to be expected that each new adventure in further socialization will fail to work quite smoothly at first; but, in the long run, we do not generally find that, where such adventures have been made and carried out in the proper spirit, there has been general clamor for a reversion to the ancient rule of "every town for itself, and the devil take the hindmost."

OBSERVATIONS OF SOME EUROPEAN WATER PURIFICATION AND SEWAGE DISPOSAL PLANTS*

BY EDWARD BARTOW

During a trip to Europe in the summer of 1914, some of the European practices in water purification, in sewage disposal, and in laboratory control were observed. No special outline was made for the trip, beyond a plan to visit certain prominent men who would know the latest developments along the lines to be investigated. No definite schedule was planned, so that places off of a regular line might be visited, in accordance with the instructions of the men consulted. After August first, owing to the war, nearly three weeks of a gradually developed schedule had to be abandoned. It was impossible to carry out plans to visit Strasburg to see the fish ponds used for sewage disposal; Lunéville to see the water purification by means of ultra-violet rays; Frankfort, Cologne, the Essen district and Ghent, to see special methods of sewage disposal. No attempt was made to see any plants in the neighborhood of Paris. In London all permits to visit the reservoirs of the water department had been withdrawn, and armed guards watched the reservoirs day and night.

Many of the European water purification plants and sewage disposal works have been described by others, an attempt will be made, therefore, to describe only what seemed to be unique. Owing to the fact that water purification and sewage disposal are so closely related, a chronological order will be followed in the observations.

Hamburg was the first city visited. The water supply of Hamburg is taken partly from the Elbe River and partly from wells. The water works are located on the river above the city, but, the Elbe being a tidal water, at times the sewage polluted waters of the river reach the intake. It is customary only during the ebb tide to pump the water into the large settling basins. Altona which adjoins Hamburg down the river, obtains its water supply

* Paper read before a special meeting of the Illinois Water Supply Association (Illinois Section of the American Water Works Association), November 11, 1914.

from a point below the sewers of both cities. Reversing the practice of Hamburg, Altona pumps water into its purification works only during the flood tide. The Elbe River through Hamburg and Altona is therefore like a large tank disposing of the sewage which is passed into it. The only treatment Hamburg sewage receives is screening through revolving screens composed of aluminum bars about one foot long, placed about one centimeter (a little less than one-half inch) apart. The flow of the water in the river averages 1200 cubic meters per second. The dry weather flow of the sewage is 3 to 4 cubic meters per second, and the wet weather flow 20 cubic meters per second, so that there is ample dilution to prevent any nuisance, and to allow the water to be satisfactorily purified for drinking purposes. At the water purification plant alum is used as a coagulant prior to sedimentation. It is thought that Hamburg has the only purification plant on the continent where a coagulant is allowed. The water, after passing through large sedimentation basins, is filtered through slow sand filters (Fig. 1). These filters are uncovered, and in winter are covered with ice. Owing to the fact that there is a prejudice against the use of water taken from the river, the water department is endeavoring to develop a ground water supply. A number of wells have been sunk, and considerable water obtained, but the Hamburg authorities are handicapped by the fact that there is not sufficient area in Hamburg for proper development of ground waters. Hamburg is unable to extend its well system into Prussia, and, for the disposal of its sewage, has purchased from Prussia an island in the lower Elbe. The situation is similar to one in this country, where New York City cannot go outside of New York State to Connecticut or New Jersey for its water supply. The ground water obtained by Hamburg contains so much iron that iron removal plants have been constructed.

While the sewage from the city of Hamburg itself is easily disposed of by the dilution method, several of the smaller cities under the direction of the Hamburg authorities are located so far from the river that another means of purification is necessary. At Berge-dorf, a city of 15,000 inhabitants, located about ten miles from Hamburg, no water whatever is available for sewage dilution. Purification is accomplished by Imhoff tanks and sprinkling filters, followed by fish ponds.¹ This is a modification of a system of

¹ K. Allen, *Municipal Engineering*, 47, 197-201.

gravity filters built in the original reservoir. The water passes through coarse sand on which manganese removing algae have been developed. These filters are washed by reversing the current, and are probably the nearest approach to the mechanical gravity filters in use in the United States. The second plant consists of pressure filters. One-half are filled with manganese permutit and half with gravel on which a manganese removing organism has been allowed to develop. Both processes are satisfactory, but owing to the economy of the sand and manganese removing organism this process seems to be better than the manganese permutit. A very satisfactory account of the experiments performed at Dresden is given by Tillmans.⁵

Reinsch screens have been recently adopted at Dresden for sewage treatment. The dry weather flow is taken care of by one screen. The storm water sometimes requires four to be put in operation. Without further treatment the sewage is allowed to flow into the Elbe. There is sufficient diluting water to render the sewage innocuous.⁶

No photographs could be obtained of a sewage disposal plant at Coethen, as the plant was visited during a heavy rain storm and photography was out of the question. This plant has been designed by Baumeister Benzel with Dr. Dunbar of the Hamburg Hygienic Laboratory as consultant. By settling ninety-two per cent of the suspended matter is removed, and the sludge is withdrawn before it has time to putrefy. In the bottom are sixteen transverse divisions, each sloping to a trough to which the sediment settles. When this sediment is to be removed, a sliding door separates the trough from the upper part of the tank. The opening of a gate on the side of the tank allows the greater part of the sludge to flow out, the balance is drawn out by means of a hoe. The gate is closed, the trough filled with water and the sliding door opened without any disturbance of the liquid above. The effluent from the tank passes to sprinkling filters which are well constructed with an outside concrete retaining wall of a special design. In the center is a specially designed piece of concrete so arranged that the underdrains can be flushed out with hose whenever desired. Green algae were growing in the effluent drains, showing a very satisfactory purification. Owing to the fact that the plant is new, and that it takes care of both sanitary sewage and

⁵ *Journal für Gasbeleuchtung und Wasser Versorgung*, 57, 713-24.

⁶ Datesman, *Journal of the American Water Works Association*, Vol. 1, 365.

storm water, and that comparatively few sanitary connections have been made, the plant should receive a more extended trial before the design is unreservedly recommended.

At Magdeburg the Puech-Chabal filters of the Magdeburg water system were visited. Magdeburg has the only large plant of this kind. The authorities are apparently satisfied with it for they are doubling its size. At Magdeburg they use not only the prefilters, but also the so-called rapid filters and final sand filters. It may be necessary to take such precautions with the water from the Elbe, but the installation is certainly very expensive and the cost of filtration must be high. A very good description of these filters is found in *Engineering*, 89, 117, 132, 164.

At Munich the sewage without any purification whatever is allowed to flow into the swift flowing Isar River. Sewage purification is unnecessary because the water below the city is not used for drinking purposes and is too cold for bathing. The engineer stated that within sixty miles all traces of sewage had disappeared. Owing to the outbreak of the war, Munich was the last German city visited.

The cities visited in Germany furnish a good series of illustrations of sewage disposal methods, from straight dilution up to the most thorough treatment.

Owing to the war the London water works were under an armed guard, and it would have been necessary to obtain special permission to visit the plant. Under those circumstances it seemed unwise to ask the authorities for the special favor.

An interesting plant visited in England was the water softening plant of the Woolcombers Ltd. at Bradford, where 50,000 gallons per day of water having a hardness equivalent to thirty grains per gallon were softened to zero by lime, soda and permutit. Permutit alone was not satisfactory and the combined soda ash, lime, permutit plant was installed. The water is first treated with lime and soda, passed through a settling tank, then over calcium permutit to remove the suspended matter and excess of alkalinity. A permutit filter gives the final product of zero hardness. The process is said by the chemist and superintendent to be very satisfactory. Two pounds of soap per grain per gallon per 1000 gallons is the saving made. This is a saving of 60 pounds per thousand gallons.

The largest and probably the only municipal permutit water softening plant is located at Hooten, near Liverpool. This plant was built to furnish a water guaranteed to have less than ten

grains per gallon of hardness. The original water contains about thirty grains per gallon. Two-thirds of the water is reduced to a hardness of zero, and is then mixed with one-third its volume of the original water. Owing to lack of time, the plant was not visited, but, in an interview Mr. Bettle, the superintendent, stated that the process was satisfactory, and that, if it were necessary to enlarge the plant, the same process would be used.

An interesting feature in sewage purification, aëration, was observed at Manchester. The preliminary experiments have been described in the 1914 *Annual Report* of the Rivers Department of the Corporation of Manchester. This process in brief consists in blowing compressed air through sewage until what is known as activated sludge is developed. This sludge added to sewage and stirred by air has the property of purifying the sewage very rapidly. For example, with a tank containing 1300 cubic feet in which are 300 cubic feet of activated sludge, 1000 cubic feet of sewage can be treated every six hours, or 4000 cubic feet of sewage can be treated daily. This allows four hours for treatment, two hours for settling, emptying and filling. It is claimed that by this process a sewage effluent can be obtained which is in better condition than an effluent which has passed through Imhoff tanks and sprinkling filters. If the claims of the process are borne out by further experience, it is expected that considerable sums will be saved in the construction of sewage purification works. Professor Fowler, under whose direction the experiments have been carried out, has consented to serve as advisor for carrying on experiments in the laboratory of the Water Survey. Later his services would be available as consultant for the construction of plants on a larger scale.⁷

To show the stress under which water works men are working, it need only be stated that in one place six rifles were leaning against the wall of the office, and the superintendent stated that the three plants of his company were watched by armed guards night and day. The men in charge of the various plants visited were very cordial, and, even after war broke out, when many of the assistants had volunteered and extra work devolved on those left, most courteous attention was extended.

⁷ Ardern and Lockett, *Jour. Soc. Chem. Ind.* 33, 523-39.

THE ACQUISITION OF PRIVATE WATER PLANTS BY MUNICIPALITIES

BY B. M. WAGNER

The first attempt at a scientific analysis of the above subject seems to have been made by Mr. Wynkoop Kiersted in a paper published in the *Transactions of the American Society of Civil Engineers* in 1897. Mr. Kiersted in that paper foreshadows the now generally adopted idea of a going value in addition to the physical value of the plant proper, as may be seen from the following extract:

The present value of a plant embraces both the plant and the business resulting from the use of the plant.

Since that time much has been written on the question of valuation, etc., for the purpose of rate making, and comparatively little on the valuation of a plant for the purpose of condemnation.

With the increase of the practice of establishing state commissions having jurisdiction over all matters of public utility, prospects are good for some uniform method of valuation for the taking over of such properties being formulated. At present, where a water works plant is to be taken over by a municipality, it is generally acquired by one of the following methods:

1. Voluntary agreement.
2. By a definite provision contained in original franchise.
3. By due process of law, as where a water works company has violated some of the terms of its franchise.
4. By direct legislative action.
5. By action on the part of the Public Service Commission having jurisdiction.
6. Where a smaller municipality has been absorbed by a larger one, the original rights are nullified.

1. In case of a voluntary agreement it is customary, after the general terms of the taking over have been agreed upon, to legalize such action by a local ordinance, or by a vote of the citizens of the municipality. Such an ordinance usually fixes the number of, and method of appointing official appraisers, etc. The usual practice is

to have three appraisers, one to be selected by each party to the agreement, and the two selected to select the third. As a rule such voluntary agreements provide that both parties will accept as final the decision of the appraisers, and the results will largely depend on the ability and honesty of the men selected.

2. In some states all franchises are limited by law so as to give the community served the right to take over the works of a water works company at any time, upon due notice and after an appraisal, the rules for which are fixed either by the franchise itself or by the laws of the state. Maine and Wisconsin are among the states that provide for such indeterminate franchises. In other states franchises are only granted for limited periods with provisions for renewals or taking. Even when no general state regulation exists it has been the practice in some localities to provide for the contingency of a possible taking, and the method to be followed, by due provision in the franchise.

3. Where a water works company operates under a franchise that contains definite stipulation to pressure, quality of water, service, etc., and it violates any of these stipulations, it can be deprived of its franchise by law, and the community affected can, in such an event, either take over the plant at a legally determined valuation, or it can build its own plant. To quote a case in point:

In a certain village where the supply was adjudged inadequate, the village obtained not only the right to construct and operate its own plant, but was also given the right to enforce a tax on the offending water company's property for the purpose of installing such a municipal water plant. See *Beauty Springs Water Company vs. Village of Lyons Falls, New York*—134 N.Y., S. 290.

4. Where a water works company is operating under a perpetual, or a long term franchise that has not expired, and the community served by said company desires to acquire the water works property, it can do so by direct action through the state legislature, under what is known as the right of "eminent domain." The United States Supreme Court has ruled that "eminent domain" is superior to franchise rights and that a franchise is merely property, and as such may be taken for the public good, provided that the same is taken in such a manner as will not violate the fifth and fourteenth amendments of the Constitution of the United States. (Sec. 166 U. S., p. 693 and 115 U. S., p. 673.) In other words, a franchise, perpetual or

otherwise, is property, and has a value that can be legally determined. The franchise as well as other property may be taken for the public good, provided that its owner is paid a legally determined fair value. In law a corporation has the same status as a person.

5. Where a water works plant is taken over under Public Service Commission regulations, it is simply a matter of action under a legislative function that has been delegated by the Legislature to the Commission.

In the *Contra Water Company* case, the United States Supreme Court decided that the legislature had the right to delegate any of its functions to a commission or other subordinate body, and such commission had in all matters so delegated, all legislative powers when exercised in the manner for it provided.

6. The only case the author can find where a water company lost what it claimed were exclusive rights by the annexation of a community served to a larger political body, was that of the *Rogers Park Water Company*, operating in a village that was annexed to Chicago. The word "exclusive" appeared in the original franchise, but the Appellate Court ruled as follows:

But certainly the fact that the life of the corporation which is alleged to have made the exclusive and estopping contract has ceased, that the territory involved has become a part of the city of Chicago, that in consequence the taxing power of the city has extended itself over the inhabitants thereof, and that their property must be taxed equally with all other citizens of Chicago to make up a deficit in the water revenue of the city, if there should be one, does not detract from the force of the argument against the contention of the appellant. It is not possible on the contrary, that the citizens composing the village of Rogers Park, now a part of the city of Chicago have a legal, equitable and moral right to demand that the city of Chicago should give them their water supply on the same terms it gives such supply to other citizens.

No matter what method is adopted for taking over a water company property, the one thing insisted upon by commissions and courts alike is "that the price to be paid must be the fair value of the property taken at the time of taking." Both commissions and courts, however, are very chary of defining strictly what constitutes a fair value. The various elements that enter into a valuation may be defined as follows:

1. The value of the physical plant.
2. The value of the franchise (if any).
3. The going concern value.

4. The market value.

The allowed value may be any one of, or a combination of the above elements, depending upon circumstances and the appraisers.

PHYSICAL VALUE

This may be arrived at in various ways, some of which are enumerated below:

- (a) Actual original cost.
- (b) Actual original cost, less depreciation and plus appreciation.
- (c) Cost of reproduction, new.
- (d) Cost of reproduction, new, less depreciation, etc.
- (e) Cost by valuation inspection.

In getting at the cost or value of the physical plant, the actual original cost can seldom be ascertained. As a rule a water works system does not come into being as a complete and finished unit, but is constructed piecemeal in a manner that the growth of the community and its demands for water warrant. As the plant begins to depreciate from the moment it is put into service, and additions are made from time to time, it is easy to see that no allowance that does not take into account both of the above factors will be a fair one.

Land value and water rights, on the other hand, may sensibly increase in value, and obsolete or inadequate machinery may be abandoned or scrapped. Taking into account all these factors, the courts and commissions, as a rule, have adopted the "Cost of reproduction, new, less depreciation method," as the fairest to both sides. Such "cost of reproduction" need not necessarily mean an exact duplication of the existing plant. The courts have decided that such cost shall be understood as for a plant of like capacity and efficiency. The most recent ruling of the United States Supreme Court was that the value to be fixed was to be obtained by deducting depreciation from the cost of reproduction, new. Such cost of reproduction may be based on present conditions and prices, or present prices and original conditions, or on original prices and conditions. Marked differences of opinion exist as to which of the above methods is correct.

The courts favor existing conditions and prices, which seems right, as what is sought is the fair value of the property to be taken at the present time. A special committee of the American Society of Civil

Engineers, however, in a report on valuation for rate making, seem to favor using present prices and original conditions. They cite to fortify their attitude the damages, etc., allowed for, apart from the actual price of land, the moving of buildings, and other factors that were met with in the building of the Wachusett reservoir. As indicating the attitude of the courts, however, it may be here stated that, in a recent Minnesota Railroad case, the United States Supreme Court ruled that the value to be allowed for land would be only what other land in the same vicinity was worth now. In an article written by Mr. Alton D. Adams on the valuation of water works, in 1912, he advocates the using of present prices in connection with actual inventory, deducting from the value so obtained the depreciation. He advocates further reductions or deductions in the following cases:

1. No allowance for discarded types of machinery or other equipment of such a nature that no one would think of duplicating at the present time.

2. No allowance for parts of plant abandoned, i.e., not in use because replaced by newer or better equipment. He quotes as an instance a case where an entire pumping station was not valued because it had become inadequate and had been replaced by a larger station.

3. No allowance for mains that are too small to properly perform their functions. He quotes in this instance a case where large amounts of 3 inch and 4 inch pipe were omitted from a valuation as these sizes were considered too small to be of any use whatsoever for fire protection. Other authorities, however, contend that such pipes, if actually in use, must be allowed for.

4. Where the present increased value of land could only be realized by scrapping or removing the plant, and so incurring a loss, he advocates allowing only such value for the land as would cover the cheapest land that could be acquired, in a locality equally desirable and useful for the purpose intended, as the land to be taken. Mr. Adams quotes a case where the land was valued at \$150,000, but the court only allowed \$15,000 for the purpose of the valuation. As he does not give the details of the case, it may, however, have been a rate valuation.

Depreciation has been defined by a recent writer on the subject as "the lessened money value caused by physical deterioration or by lack of adaptation to function." Needless to say that the measure of deterioration is not always the measure of depreciation. The

methods of arriving at the measure or extent of depreciation are practically the same as are used in rate cases, namely: actual appraisal, calculation on the sinking fund method, calculation on the straight line method. The only one of these methods that seems to be a proper and fair one is the actual appraisal method. Both the sinking fund and straight line methods, with their assumption in the first place of a value arrived at by deducting from the actual cost of sum representing the accumulation of annual cost increments for the past life of the plant or article being valued, are fallacious, and to the author's mind both these methods find their application only in rate fixing. The value as given by either of them is not applicable to purchase cases.

The actual value can best be obtained by an actual personal appraisal, and must be measured by the actual probable remaining life value of the equipment appraised and the scrap value at the end of such life. For instance, a pump or boiler may have theoretically ten years of life remaining, but conditions may be such that it will have to be replaced in a much shorter time, or, on the other hand, it may have been so well maintained that its probable useful life will greatly exceed its theoretical life. In either case only a direct appraisal would be a just criterion of its value.

Appreciation, as a rule, is only possible in the item of land or water rights. In both these cases appreciation, if any exists, should be allowed for. However, in the case of land, values only attainable by losses on other parts of plant should be properly diminished. Discarded or unused plant should be excluded from valuation, or, at the most, its scrap value allowed. The Wisconsin Commission excludes all discarded or unused property except such as is retained for emergency reserve. The court decisions are, in general, to the effect that only property actually used, or useful, in supplying water at the time of valuation shall be valued.

Valuation by direct inspection and appraisal, while it involves in a measure the personal equation of the appraisers, and has, to some extent, fallen into disuse under the commissions, is still used as a check on valuations arrived at by other measures. Book valuation would only be possible where first class continuous written data existed, covering not only first cost, but also the cost of all subsequent additions, and having written off all superseded plant at the time of its being superseded; even then the depreciation would have to be accounted for.

THE VALUE OF THE FRANCHISE

The value of the franchise, where any exists, is nowadays apt to be considered as part of the Going Concern Value, but, as cases have arisen where franchise value as such has been given separate recognition, it may be well to take it up as a separate factor.

A franchise to have any value must have a definite life, and must provide for privileges to the holder that have an actual value. A franchise with only a few years to run, and that permits of a rate regulation, or that is revokable at will or is otherwise subject to regulation, has but little, if any value; on the other hand a perpetual or long term franchise with a fixed scale of rates, that allows its holder to earn an income, giving a large rate of return on capital actually invested, has a value that must be allowed for in a valuation of this kind.

The courts have decided that a franchise is property, and its fair value must be paid when taken for the public good. Various states have different methods of dealing with the Franchise Value question. In Massachusetts municipalities are granted competing franchises unless the water companies agree to sell on such terms as will exclude franchise values. In Wisconsin many water companies have voluntarily given up term franchises for indeterminate commission permits, which, while they secure the companies against competition, cannot be capitalized in cases of municipal purchase.

The date on the life of franchises given in Table No. 1 should be of interest as bearing on the possible franchise value in different states.

GOING CONCERN VALUE

Apart from the value of an operating water works plant as a physical unit, there exists a certain value due to the fact that it is operating, has customers and an income; this value is what is known as "going concern value."

Such a value may or may not, as the case may be, include the franchise value, but in any case it exists independent of a franchise value. Table No. 2 gives a few decisions that have been made on the subject of various valuations, but it is only fair to say here that the tendency nowadays is more and more towards recognition of such going value. The actual measure of this going value is, however, a subject of dispute. Mr. J. W. Alvord states, "going value is the value of the created income, or the cost of reproducing a given

income." Mr. Benezette Williams states, "Going value is the potential business value, the amount of which must be determined by the net income which a plant in operation can produce in excess of what a substitute like plant can produce." Mr. Williams and Mr. Alvord agree that the going value is the value of the created income, but differ as to the method of arriving at such value.

The Wisconsin Commission in the Antigo Water Company case, August, 1909, decided that the going value should be measured by actual investment rather than by a valuation of the created income. Mr. Alvord uses what is known as the comparative plant method. In other words he assumes a new plant just starting, and figures what it would have to expend, and what the existing operating plant will receive before the new plant arrives at the same measure of income as the existing plant has.

The New York Public Service Commission, First District, disapproved the comparative plant method. The United States District Court, in a San Francisco rate case, also disapproved the comparative plant method.

The general premises on which going concern values have been based are as follows:

(a) Estimated deficits that would be incurred before a new plant could equal the present business of the established plant.

(b) Estimated deficits that would be incurred before a new plant would be on a paying basis.

(c) Actual deficits that were incurred before the existing plant was brought to a paying basis.

(d) The same as (c) except that from it be deducted all amounts over a fair rate of return on actual investment that the plant has made since it has been on a paying basis.

None of the above rules have any particular court sanction. In most cases the courts have merely made an allowance for going value, but have not in any way indicated by what process their decision was arrived at.

The Wisconsin Commission in the Antigo case used a method based on the rule that "certain costs of development in the first years of a plant's existence may be added to the plant cost charge, and form the 'going concern value.'" The method was as follows:

Beginning with the first year the plant was charged with cost, new extensions, interest, depreciation and operating costs, and credited with the gross earnings of the year. The balance was carried

forward to the second year and the process repeated, and so on for each year of the plant life. The balance, at the end of the last year considered, was regarded as the value of the plant on an earning basis at the end of the period.

In 1911 in the case of the city of Marinette *vs.* City Water Company, the commission decided that the amount by which the earning value exceeds original cost plus extensions is to be taken as the measure of going value. The commission states, however, that not all failures to earn a fair income shall be capitalized as going value. The rule must be applied with care, and must not be taken to include losses due to poor judgment or to lack of ordinary care, foresight and efficiency. The Wisconsin rule, so far as the author can find, has not been put to court test.

In a recent case of "taking," involving a street railway valuation, Mr. B. J. Arnold used the following as one of the methods of getting at the value of the property taken. It is along the line of the method adopted by the Wisconsin Commission, and Mr. Arnold states that it has been used abroad in railroad condemnation cases. The method is as follows:

Take each year the actual investment in the property, deduct the value of all superseded property in the year it was superseded, and estimate what would be a fair return on the net investment. Deduct from such return the net income after paying operating expenses, including maintenance, renewals and taxes, charging to operating expenses all superseded property in the year it was superseded. Then, compound each year the deficit or surplus, as the case may be, between the fair return and the actual net income. The result will be a sum of the accrued losses estimated upon the return at a given reasonable per cent. The total accrued loss plus the physical value will be the fair value of the property.

In general the courts have based their decisions on the value of an established business rather than on the cost of establishing the same as measured by past losses.

Where a water company is operating under a fixed rate franchise, the franchise and going concern values become one, and the value itself may be based on a capitalization of its excess income. Going concern is not considered as representing what is known as goodwill. The highest court in this country has held that, from the nature of the service, a water company is virtually a monopoly, and, as such, no goodwill can exist.

The following examples of actual decisions by the Wisconsin Commission may be of interest:

FOND DU LAC WATER COMPANY, AUGUST 19, 1910

Cost of reproduction, new.....	\$314,439.00
Cost of reproduction, new, less depreciation	281,922.00
Original cost, plus additions to 1910.....	310,165.00
Earning value at 6 per cent (Market Value).....	307,166.00
Commission allowed.....	320,000.00

APPLETON WATER WORKS COMPANY, SEPTEMBER 7, 1910

Cost of reproduction, new.....	275,781.00
Cost of reproduction, less depreciation.....	240,168.00
Commission allowed.....	255,000.00

MANITOWAI WATER WORKS COMPANY, JUNE 27, 1911

Cost of reproduction, new.....	\$242,510.00
Cost of reproduction, new, less depreciation.....	223,108.00
Original cost, plus additions to 1910.....	233,183.00
Earning value at 6 per cent.....	231,357.00
Commission allowed.....	236,000.00

The market value of a plant where used includes all elements that go to make up the value of the plant as a business, and is generally based on its earning capacity.

Where a long term or perpetual franchise with fixed rates is involved, the market value seems to be the only reasonable basis for an award. In other words, if, by reason of its franchise, a water works company was allowed to charge rates that gave it a return of more than 6 per cent on its actual outlay, over and above its operating expenses, taxes, depreciation, etc., such surplus income, for the purpose of its unexpired franchise, would have a definite value that would have to be paid for. As a case in point, the following railroad case is quoted, the principle involved being the same:

Mr. B. J. Arnold in the Metropolitan Street Railroad case, 1913, based a value on the following premises:

- (1) Rights that now exist will last to 1925.
- (2) Net profits for each year estimated by the following method:
 - (a) Gross receipts, less operating expenses (which include maintenance, depreciation on present value and taxes).
 - (b) Less fixed interest charges upon depreciated tangible value of the property as then found.

The net returns thus found are discounted at 5 per cent per an-

num, to get present value. From this value deduct the present value of the future interest charges that must be met to supply the constantly increasing capital needed to produce future earnings. The net result is the present going concern value.

INVENTORY

The matter of making an inventory of the physical property of a water works plant can be divided into two divisions which may be roughly classified as field and office work.

The field classification covers the listing of all property that can be actually visualized in the field. Where prices are affixed in such field lists, they must be considered merely as supplementary information, and should, in no case, be used by the office force for final results unless properly verified.

To simplify the field work and insure uniformity of results, proper blanks should be prepared for the use of the field force, covering the various classes of items that are to be listed. As models for such blanks or forms, the forms used by the Wisconsin Commission for this purpose are suggested, as they are probably the best now in existence. All field notes should be kept in duplicate, preferably by using carbon sheets for making duplicates. The original sheets should be turned in to the office force at intervals not more than one week apart, and the duplicate retained by the field force. A proper system of numbering should be used, and each article listed should have its number plainly marked on it, to prevent confusion or duplication. In the event of further information being obtained about an article listed, or errors being discovered in a like case, corrections should be made on the field copy, and the office notified on a special form as to the corrections to be made, giving serial number, etc.; carbon copy of such correction sheet to be held by field force and attached to its records. In all cases condition of article should be noted, and, in the case of supplies and tools, the designation might be, new, used, still usable, and scrap. In listing machinery, boilers, etc., the Wisconsin classification of G, F and P may be used to advantage. In the Wisconsin code "G" indicates that the item is to be depreciated for age only; "F" indicates a 90 per cent of "G" value, and "P" indicates an 80 per cent of "G" value.

While the field force is organizing and getting started, the office force should be employed in making up as far as possible a separate

inventory from such records as are available. This inventory will serve as a check on the work of the field force; in the case of any glaring discrepancies try to obtain an explanation or adjustment of the same.

Some items will probably only be obtainable from the records. The office force must also prepare lists of standard prices that will be applied in making up the costs to be adopted. After the lists are all made up, prices applied, extensions made and preliminary summaries compiled, it would be well to have the main items looked over in the field by experienced engineers, to determine the actual depreciation as compared with that determined by the field observers, or computed by the office force.

The determination of the proper prices to be used, and extent of depreciation, are the two most delicate factors that occur in the physical valuation, and must be handled with care. To cover errors and omissions it is the custom nowadays to add an allowance of from 5 per cent to 15 per cent of the total inventory value to such value.

The various factors that make up the inventory are briefly as follows:

Mains, valves, hydrants, etc.

For a schedule of mains the records will, as a rule, have to be depended upon; the valves and hydrants can be checked up by the field force. The field force will have to note condition and class of pavement, supervise such excavations as are made for getting at depth of cover and condition of mains. The office force will have to make up the schedule proper, and get what additional information is required in the matter of pavements. Where grave discrepancies between records and field notes exist, or where no records are available, it will be necessary to get at the facts by actual location of gates and hydrants in the field with excavations at intervals to determine sizes of mains. Cost of such extra work should be charged to the water company.

Structures

All large structures such as filters, reservoirs, intakes, etc., will, in case plans or records of their construction are in existence, have such plans or records checked by the field force. Where no plans or records are available, the field force will be required to make such surveys and notes as are needed in order to get at quantities. Con-

ditions must be noted in all cases. It may be noted here that it is more than probable that, in the absence of records, the cost obtained will be less than the actual original cost.

Buildings

What has been said about other structures holds good for this item also. In no case should the cost or value assumed be based on cubical contents only.

Boilers, machinery, pumps, etc.

Each boiler pump, feed pump and main auxiliary should be listed separately. All steam piping, fittings, valves and pipe covering should be listed separately as to size, condition, age, and all obtainable information should be noted carefully. All suction and discharge piping should be listed in detail. Foundations for boilers and machinery should be listed in detail, with particulars of nature of soil, ground water elevation, etc.

Driven wells

Where driven wells form the source of supply, the field force can do but little more than get the number of wells, etc., size of casing and total depth. If no records are available on size, length and nature of strainer, a very small allowance should be made for same. It might, in some cases, be necessary to withdraw and redrive a well in order to settle disputed points.

Supplies, tools, etc.

Items under this heading should be listed as far as possible in bulk; where new, by original packages, and where in use, an average condition should be determined for each class of article.

Land

As a rule this item is taken care of by the office force, but the field force should be instructed to note character of adjacent land, nature of improvements, etc. As to prices or values the engineer must needs depend upon the expert opinion of nearby real estate

appraisers. The so-called "Sales Method" sometimes used for getting at values is merely a systematic collection of data, and comparison of the same, based on the records of sales, transfers, etc., of property in the neighborhood of, and having like conditions as the land to be appraised. Two interpretations of this method are used, the one being an average unit price per acre, lot, etc., such unit price being applied to the like unit of property to be valued; the other interpretation being based on same data, but comparing the assessed values of the known and the to-be-valued properties.

Water rights

These are in most cases bound up with land values, although in some cases a separate distinct value may be in order. In case of a large supply taken from a large lake or river that is equally available for others, no water right value can exist; on the other hand, if the water company controls the only nearby source of supply, or has, by reason of franchise rights or special laws, a practical monopoly of the only reasonable source of supply, a value exists that will probably have to be paid for.

Intangible values

Apart from the value of the physical property, every water works plant has an intangible value that may be composed of one or more factors of its existence. The determination of such intangible value is the hardest problem that faces the appraiser, and it is not easy to give any fixed rules for this purpose. As to the main factor, the so-called "going concern" value, the recent decisions of the courts seem to indicate that it is the present measure of the business value, and not what it actually cost to establish the business. If this view be taken the method proposed by Mr. Alvord probably will fix the lines along which the appraiser will work. On the other hand, if the actual cost of establishing the business be taken as the measure of its going value, the method used by the Wisconsin Commission in the Antigo case will probably be followed.

Where a direct value exists, such as a net income over and above all operating interest and other charges, due to a franchise that fixes rates, the present value of such income for the remaining life of the franchise is easily determined. While very little discrepancy need exist in physical values arrived at by different appraisers, the

speculative elements that enter into the determination of intangible values are of such a nature as to make it a very hard matter for even the fairest minded appraisers to agree on such intangible values.

CONCLUSION

In general, the acquisition of a water works plant by a municipality, whether it be by agreement or condemnation, is in its last analyses analagous to the purchase of any other mercantile business. The stock in trade, apparatus, fixtures, etc., in either case are inventoried and valued at what they are supposed to be worth at the time of purchase, and not at what they may have cost, or may be worth at some future date. The land values are taken as they exist, and if, by reason of special location or fitness, such land has a greater value than adjacent property, such value is paid for. The goodwill of the private business finds its counterpart in the "going concern" value of the water works, and if finally, by reason of some special process or patent, the private business has a special additional value, such value also exists for the water works company that has a franchise fixing rates that give it more than a normal return on its investment, and in both cases such special values must be paid for.

TABLE NO. 1

FRANCHISE CONDITIONS IN VARIOUS STATES

New Jersey:

Franchise life limited to thirty-three years, but may be made sixty-six years by a majority vote of the votes of the district or town involved.

Greater New York Charter:

Franchise life on original grants to be not more than twenty-five years. A renewal of twenty-five years at a valuation is allowed.

Illinois:

Maximum franchise life twenty years.

Ohio:

Maximum franchise life twenty-five years.

Michigan:

Maximum franchise life thirty years. The New Michigan constitution provides that all franchises granted, except such as may be revoked at will, require the affirmation vote of 60 per cent of the electors of the city granting the franchise.

Massachusetts:

Any franchise may be revoked at any time after the expiration of one year from the date of the franchise.

Wisconsin, 1907:

All future grants and all authorized companies that surrender original grants are to receive indeterminate franchises.

New York State:

In 1892 the franchise term for all water supply companies on franchises granted by municipal officers was made ten years.

District of Columbia:

Indeterminate franchises.

Porto Rico:

Indeterminate franchises.

Maine:

Indeterminate franchises.

Philippine Islands:

Indeterminate franchises.

TABLE 2

GOING CONCERN VALUE DECISIONS

1. Kansas City Water Works: United States Circuit Court of Appeals in 1894. Added for established business to value to be paid. This is the leading case in such matter.
2. Gloucester, Massachusetts: Water Plant Purchase, 1899-1901. Allowance made for Going Concern Value.
3. Bristol, Rhode Island. Water Plant Purchase. 1901. Going Concern Value not allowed.
4. Mobile, Alabama. Water Plant Purchase, 1903. Going Concern Value not allowed.
5. Galena, Kansas. Water Works Purchase 1910. Going Concern Value allowed.
6. Maine, 1902 and 1904. Going Value allowed.
7. Omaha, Nebraska. Case, May 31, 1910. United States Supreme Court, 218 U. S. 180, 30 Sup. Ct., 615, 54 L. ed 991. Going Value was allowed.

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THE CINCINNATI WATER WORKS

BY JOHN W. HILL

In the following brief paper on the Cincinnati Water Works it is not intended to do more than roughly sketch its history and call attention to some of the more interesting events in its development.

Unlike many city water works constructed at later date, the public supply of this city has gone through all stages from the leasing to consumers of a "privilege" to raise ground water by windlass from a privately owned well to the pumping of water from the river by the highest type of engines, and delivering this after elaborate filtration, under pressure, to the consumers.

"Water works" of the primitive kind were established in this city as early as May, 1799, long before cast iron pipes, high duty pumping engines and filtration were known. But at that date the sources of supply were either springs on private property or shallow dug wells, from which the consumer drew his water supply into a bucket or barrel and carried or hauled it to his home. The enterprising citizens who owned good springs, or wells, were careful to make a charge for the use of water from them, and in one instance the owners of a well charged as much as four dollars per year to each consumer for the water privilege, the consumer being required to furnish the motive power to turn the windlass and raise the water from the well. This charge nearly, if not quite, reaches the minimum charge in some of our cities today, where the water is delivered to the consumer through cast iron pipes under pressure.

The privately owned supply for public uses did not continue long, for early in the past century (1809) wells were dug at various places about the town and equipped with windlasses, ropes and buckets, and the cost of these was assessed on the real estate tax duplicate.

The labor of raising water by a windlass did not appeal very strongly to our municipal ancestors, and soon this method of public supply was exchanged for a barrel or tank mounted on wheels and drawn by horses or oxen. The tank wagon was hauled down to the river and filled with a long handled tin ladle, and when full the

carrier distributed the water to his customers. A large number of these water venders doubtless were required to supply the necessities of the town; but this method was the most advanced for the supply of public water until July, 1821. It will be noted that the method of public water supply of the town, if it can properly be called such, was quite like our milk supply at the present time. For a period of about twenty years the water was hauled from the river and delivered to consumers by these tank wagons. The per capita consumption must have been small; but the cost per gallon delivered must have been relatively large, when compared with the modern cost of purveying public water supplies.

Other cities than Cincinnati have been compelled in their early history to depend upon tank carts and wagons for the daily water supply, and it may be of interest to note that our late lamented member, Mr. Emil Kuichling, employed this method of water delivery in estimating the value of Spot Pond Reservoir to the Boston Metropolitan Water System, assuming that the equivalent of the Spot Pond gravity supply through pipes could be obtained by water delivered to the consumer by water venders, and that the value to the Metropolitan System of the natural supply at an elevation above Boston, etc., might be determined in this primitive way. Of course the value thus obtained was high, in fact several times the amount reached in their decision by the board of auditors (Messrs. Benton, Bumpus and Stiles).

The growth of population and demands for water having outrun the "Mosaic" method of supply, one of the enterprising citizens, a wagon maker by the name of Reeder, devised a crude chain pump, mostly constructed of wood, with which he lifted the water from the river and delivered it into a shallow wooden oblong tank containing about 40,000 gallons. But this small body of water in an open reservoir exposed to the sun soon became stagnant and the public refused to buy Reeder's water, and cast about for a more modern method of supply for public uses.

At that time (1817) one of the foremost men in Cincinnati was a Mr. Samuel W. Davies, who was associated with a Mr. Jacob Findley in a woolen-mill, a white lead works and some other early manufacturing operations, under the title of The Cincinnati Manufacturing Company, and to Mr. Davies the Town Council went with an appeal to establish a power pumping works and distribute the water through pipes to the consumers, and also to erect pen-

stocks (fire hydrants) on the lines of pipe for fire protection. In due time an ordinance was passed giving Mr. Davies and his associates a ninety-nine year franchise with no restriction on the charges for water for domestic uses, and no compensation for fire protection. In addition, Mr. Davies and his associates were required to pay the town one hundred dollars per year for the franchise.

The charter of the company, one of the earliest written for a privately owned water works in this country, is brief, and for the benefit of those who may not know how such things were done a hundred years ago, it is here quoted in full.

The ordinance or charter reads as follows:

Section 1. Be it ordained by the Town Council of the town of Cincinnati, That the Cincinnati Manufacturing Company, their heirs, successors and assigns, shall be, and they are, hereby vested with the exclusive privilege of conveying water, by tubes or otherwise, from the Ohio River, through the streets, lanes and alleys and commons of the town of Cincinnati, for the purpose of supplying the inhabitants of said town therewith; which privilege may and shall be enjoyed by the said company, their heirs, successors and assigns, exclusively, as aforesaid, for the term of ninety-nine years from and after the passing of this ordinance, on the following terms:

1. The said company shall complete the work so far as to convey the water into that part of the town lying south of Third Street, commonly called the bottoms, within two years from and after the first day of July next; and they shall convey the water into that part of the town lying north of Third Street, commonly called the hill, so that same may be delivered three feet above the first floor of James Ferguson's kitchen, in the second ward of said town, within the term of three years from and after the said first day of July.

2. After the said period of three years, the company, their heirs, successors and assigns, shall continue to supply the citizens of the town (or such of them as may desire to receive and pay for the same) with a sufficient quantity of water, making proper allowance for unavoidable accidents and for the necessary repairing and renewing of their works.

3. They shall permit water to be taken freely and without expense from their reservoirs and conductors, wherever the same shall be necessary to extinguish fires in the town, and for this purpose they shall provide for each square or block to which they conduct the water a fire plug or pen stock; and, if the Town Council shall at any time see proper to make reservoirs to be used in cases of fire, they shall be permitted to fill such reservoirs, free of expense, from the conductors of the company: Provided the said reservoir be kept tight and in repair, and the water therein be used exclusively for the purpose of extinguishing fires.

4. The company, their heirs, successors and assigns, shall pay to the Town Council, yearly, and every year during the continuance of the privileges herein granted, the sum of one hundred dollars, which payment shall commence one year after the works are completed. The money so to be paid

shall constitute a free fund, and shall be appropriated under the direction of the Town Council, in such manner as they shall see proper, in providing and preserving such articles as may be useful in extinguishing fires.

5. The said company, their heirs, successors and assigns, shall be permitted to dig in the streets, lanes, alleys and commons of the town, for the purpose of sinking their conductors and repairing them as often as may be necessary, leaving the surface of the streets as before, causing as little inconvenience to the citizens as the nature of the case will admit; and they shall be permitted to demand and receive yearly, from the persons who shall use the water from their conductors, such sum as they may voluntarily agree to pay for the same.

6. The privileges granted by this ordinance shall not be forfeited by a temporary interruption in the supply of water occasioned by accident, or the want of repairs in the machinery, reservoirs, conductors, or other parts of the works: Provided, such accidents be remedied, and such repairs be made, within a reasonable time.

7. During the term of ninety-nine years hereinbefore specified no other person or company shall be permitted to convey water through the streets, lanes, alleys, or commons of the town by tubes or other conductors for the purpose of supplying the citizens of the town with water.

Section 2. Be it further ordained, That if the charter of the said Cincinnati Manufacturing Company shall expire, or the said company be dissolved before the expiration of the aforesaid term of ninety-nine years, this ordinance and the privileges herein granted shall not hereby cease, but shall continue in full force and effect, and at the dissolution of the said company all the privileges herein granted shall vest in the persons composing the said company, at the time of such dissolution, their heirs and assigns, in the proportion of their several interests in the stock of said company; Provided, the persons claiming the privilege aforesaid comply with the terms hereinbefore mentioned.

(Passed 31st of March, 1817.)

Several interesting points are here presented.

1. The great length of the grant, which if it had not lapsed by reason of purchase of the works by the city (1839) would not expire until March, 1916, or about one year from the present time.

2. No schedule of water rates was agreed upon and Mr. Davies and his partners held that there was no limitation to the water rates they could enforce, excepting the patience and forbearance of their customers, all of whom could return to the old cart method of supply if the Water Company became exorbitant in its charges. It does not appear, however, that Mr. Davies was at any time unreasonable and as he financially failed in the enterprise, it would seem that he really pumped and distributed the water without profit.

Of course it is known that a charter was granted to a company in New York about the year 1800 for supplying water through pipes to the inhabitants of that city, and that a pumping station and small elevated tank had been erected in Center Street, and a small amount of pipe laid, in order to comply with the letter of the charter, but with no real intention of supplying water to the city. The purpose being to establish a United States Bank, rather than works of public water supply. Alexander Hamilton and Aaron Burr were members of this earlier New York Water Company. The ordinance, or charter, for the Cincinnati Water Company, however, was a bona fide instrument for the purpose of authorizing and protecting a works of public water supply and had no other motive than the supply of water for domestic uses and fire protection in the embryo city.

Some of the provisions will appear very curious to us at this distant time, for example, the limiting head to which the water shall be pumped is determined in Paragraph 1 of Section 1 of the ordinance as follows, viz.:

"Three feet above the first floor of James Ferguson's kitchen in the second ward of said town."

The location of Mr. Ferguson's residence is not specified, and if he should happen to move from one part of the ward to another at higher elevation, during the construction of the works, or perhaps even after the works were constructed, the Water Company under the ordinance would be required to increase the pressure at which the water was delivered through the mains. In other words, no fixed elevation is given.

Upon the other hand, if James Ferguson should happen to move out of the second ward altogether, before the works were finished, no limiting head or pressure is then specified in the ordinance.

Paragraph 5 of Section 1 provides that:

"They (the water company) shall be permitted to demand and receive yearly, from the persons who shall use the water from their conductors, such sum as they may voluntarily agree to pay for the same."

This is the nearest approach to a schedule of domestic water charges in the ordinance, or charter, and it doubtless led to quite a variation in the amounts charged consumers according to their ability and willingness to compensate the company for the water taken.

By paragraph 7 of section 1 it will be noted that the town council granted an exclusive privilege to Mr. Davies and his associates to occupy the streets and highways with water pipes and to supply water to the citizens of the town.

A wood cut of this first power water works for the city adorns the stationery of the local committee for this convention. This cut was drawn from a published description of the Davies Water Works at the time they were started in service (1821), and it is only fair to remark that one of the members of the local committee, Mr. Pollard, took exceptions to one feature of the cut which in his judgment did not represent good engineering practice even in 1820.

The cut is here produced for the edification of our members, and attention is drawn to the bank of earth extending out over the edge of the river, upon which Mr. Davies built the foundations for his pumping station, and by piercing the earth put the suction of the pumps into the water. The fault or mistake is to be charged to the draughtsman (1880) and not to Mr. Davies, who we are assured from his well known enterprise and intelligence never built his pumping outfit in that way.

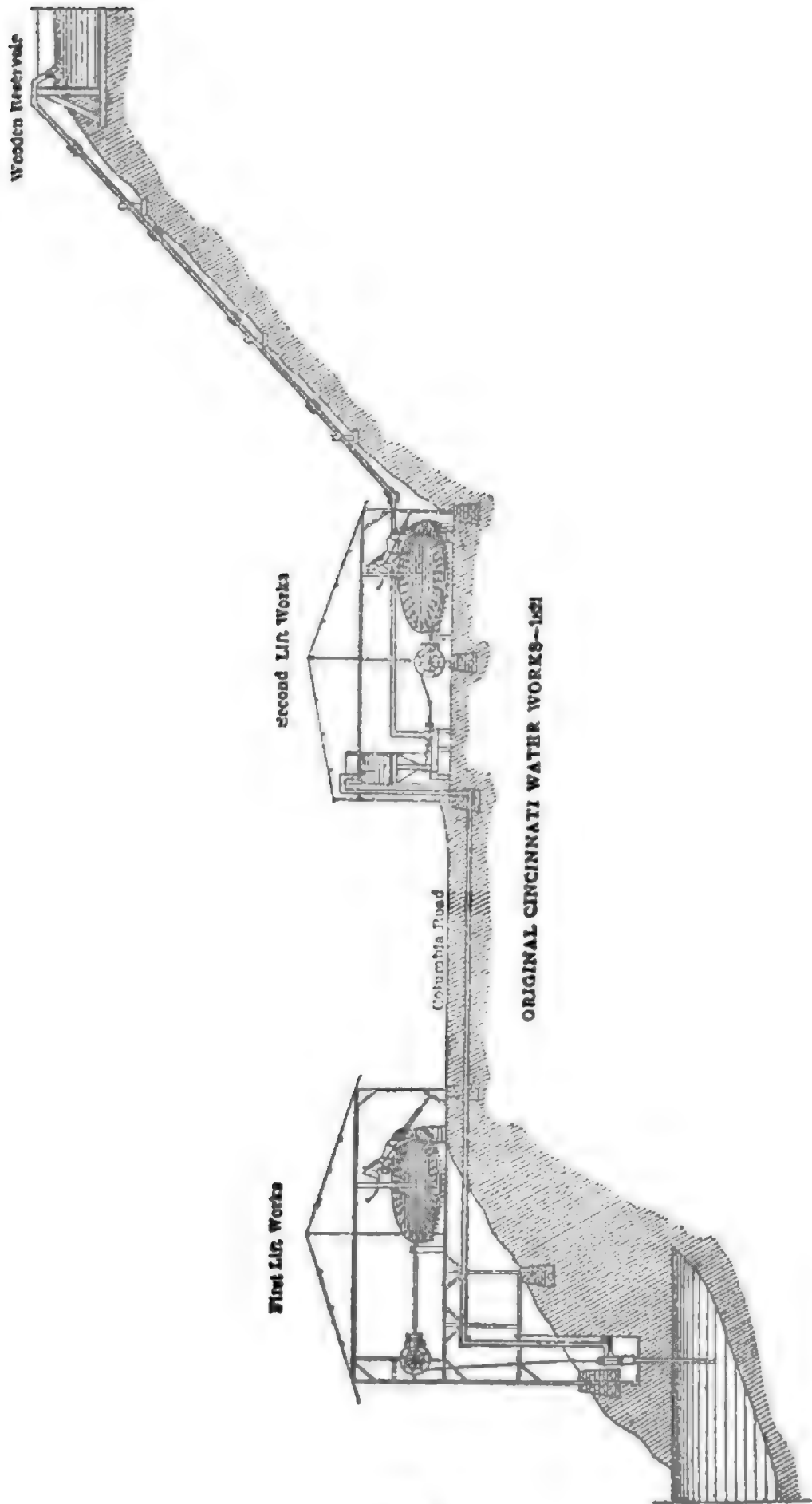
The Davies distribution system consisted of white pine and white oak logs through which was bored with a pod-auger one and one-half inch and two and one-half inch holes. These logs were banded at one end and put together stove pipe fashion by driving the spigot into the banded bell or socket.

There are no records showing how the hydrants were made, excepting that the "pen stocks," so called, were of wood.

The pumping machinery consisted of one low lift suction pump, which lifted the water from the Ohio River to a tank in the pumping house, and a so-called force pump which took the water by gravity from the tank and pumped it to an elevated wooden service reservoir. From the reservoir the water flowed by gravity through the wooden pipes laid in the streets.

The motive power to operate the pumps were horses or oxen working on inclined treadmills, and the engineer was a boy or man who regulated the power according to the demands for water.

This was the beginning of the Cincinnati Power Water Works. The service was not satisfactory, and many complaints were made on account of the frequent breakdowns, and interruptions of the public water supply, and yet at that time as the census shows the population and demands for water under pressure, or running water,



were increasing from year to year by leaps and bounds, because this city was then the foremost "settlement" west of Philadelphia, and being located on a great highway of commerce the surplus population from the Atlantic seaboard cities flocked here in great numbers during the earlier years following the second war with England.

About three years after the works were started in service, Mr. Davies installed a steam pumping engine of 1,200,000 gallons daily capacity which probably he himself designed. The steam cylinder was twelve inches diameter by five feet stroke, and the two low lift and two force pumps which it worked were each six inches diameter by four feet stroke. The engine was rated at forty horse power.

In 1828 this pump was remodeled by Mr. Anthony Harkness, who was, for the pioneer days in this section of the country, in several ways a marvel. He was one of the first to establish a foundry and machine shop to build engines for western steamboats. He saw and remedied the defects in the first steam pumping engine (Davies) ever started in Cincinnati. He designed and built the first locomotive in Cincinnati, and more than sixty years ago went abroad to obtain contracts for locomotive engines of which he was then a successful builder. Robert Fulton invented the steamboat in 1807, and not many years afterward enterprising men were busy in the West, especially here, in adapting it to the requirements of the western rivers. Among these was Mr. Harkness, and it was doubtless on his advice that the steam end of the first pumping machine was taken from a steamboat and utilized for pumping water.

We are much concerned today about the unnecessary waste of water, and are seeking by every available means to prevent or reduce it. In fact, this is the chief argument for the use of water meters, and you may be surprised to hear that the leading trouble with Mr. Davies' Cincinnati Water Works (1824) was the large unnecessary waste of water.

This needless waste of water from works of public supply has continued over a long stretch of time; it has reached from Frontinus A. D. 92, to John C. Trautwine, 2nd, 1900, and the same complaint that we are putting up today, that Mr. Trautwine put up in 1899, and that Frontinus put up to the Emperor Vespasian in 92, is still a condition to be wrestled with, and by the sympathetic and energetic efforts of the meter men may some day be laid at rest.

Mr. Davies finding that his water works would not pay, and discovering as others since have discovered, he could not borrow himself out of debt, offered (1824) to sell his works to the city for \$30,000.

The Town Council appointed a committee to examine the works and books of the water company and report on the advisability of buying the property. The committee reported favorably, but upon taking a vote, 25 freeholders were in favor and 294 against purchase.

In 1826 the water company had its charter powers enlarged by Act of the Legislature, additional capital was obtained, and Mr. Davies, who must have been an enthusiast on water works matters, set about to remedy the defects and deficiencies in the works, and adapt them more nearly to the requirements of his time.

Between 1825 and 1832, three new reservoirs were constructed on the site of the old Third Street Reservoir, just north of the old Front Street Pumping Station. The first line of cast iron water pipe was laid from the distributing reservoir in Pearl Street, west (1828). This pipe was of unusual size, viz.: eight inches diameter, and must have been obtained at that time from R. D. Wood and Company, who had started the first pipe foundry in this country a few years before at Millville, New Jersey. Incidentally it may be mentioned that this firm is still supplying cast iron water pipe, upon sufficient provocation, to those who may need it.

The unhappy condition of Mr. Davies' finances, the unsatisfactory water service to the city, and the many complaints from the injured water takers, led to another effort by the Town Council in 1832 to purchase the water works and relieve the water consumers from some of the handicaps which they had suffered since the works were installed eleven years before. The committee appointed again reported in favor of purchase at a cost of \$150,000, or five times the cost for 1824, and again the "harassed" and "indignant" freeholders and water takers voted against the purchase by a vote of 303 "for" and 617 "against."

The water company then increased its capital stock and proceeded to "enlarge the works commensurate with the rapidly growing needs of the city." To do this the company was required to appeal to the state legislature for enlarged charter powers, a proceeding which the city council at first opposed. After a lapse of three years, the council withdrew its objection, the legislature

granted the additional powers asked for and the water company started on a new career of "progress and trouble." In 1835 the water service being still unsatisfactory, the council appointed the third committee to investigate and report on the advisability of "municipal ownership" of the works. This committee reported favorably on purchase at a cost of \$273,637—(note the first offer in 1824 at \$30,000),—and the vote when taken stood 956 "for" and 1274 "against."

Two years later, 1837, the "purchase" was up again and this time the vote was 1573 "for" and 531 "against." Owing to some defect in the proceedings for the vote, a new vote was taken, March, 1839, on purchase at \$300,000, with the result of 728 "for" and 553 "against."

In 1839 therefore after a stormy and financially disastrous career of eighteen years, the Cincinnati Water Works became a municipal institution.

When the purchase occurred the property consisted of a tract of land including the site of the late Front Street Pumping Station and the Third Street reservoir grounds, now a public park. It will be noted that the city had a population in 1840 of over 46,000, while the combined pumping capacity was rated at 4,200,000 gallons per day, showing a maximum possible capacity of about 90 gallons per capita. It is probable that the actual water consumption was much less than half of this quantity, because the larger pump must have been out of service at times for repairs, when the smaller original machine, if it maintained a supply equal to the normal consumption, would have furnished less than 30 gallons per capita.

A stone masonry reservoir about 350 feet long, 50 feet wide, inside surface dimensions, and 12 feet deep, containing 1,200,000 gallons, had been constructed on the Third Street property as early as 1828. The pumping lift from the Ohio River, low water stage to the flow line of the reservoir was about 160 feet.

It must be remembered that the two earlier steam pumping machines were built during the pioneer days of pumping machinery in this country. The first engine (1824) was of the walking beam type with a wooden walking beam. The second engine had the steam cylinder located axially over the pump and drove the pump direct.

The earlier pumps were all of the piston type with swinging or "barn door" water valves resting on seats inclined at an angle of

45 degrees. Everything about the water ends was plain, direct, simple and crude, and yet these old machines contributed largely to the early development and prosperity of the city.

The property conveyed to the city contained:

- (1). The land above mentioned.
- (2). The pumping station.
- (3). Two rotative steam pumping engines.
- (4). The masonry reservoir.
- (5). Nineteen miles of wood pipe or "logs" from 1½ to 2½ inches diameter of bore.
- (6). Three and one-half miles of cast iron pipe varying from 4 to 20 inches diameter.

Looking over the inventory of property it would strike one at first sight as though the price was more than it was worth. But the people were satisfied, and it would be presumption for us at this distant date to criticise the acts of our forefathers. In 1840, the population of the city was 46,338 and the purchase price was about \$7.00 per capita of population.

When the city took over the water works the following survey rates were adopted:

Lowest consumption.....	\$10.00 per annum
Second consumption.....	\$12.00 per annum
Third consumption.....	\$14.00 per annum
Fourth consumption.....	\$16.00 per annum
Baths \$3 each, hose \$1, Garden sprinkling \$1 to \$4.	

The works were very wasteful of fuel and steps were taken to investigate a possible water power from the Miami and Erie Canal near its entrance into the Ohio River just below the pumping station; but upon investigation it was found that the proposition was not feasible.

Several years before the water company sold its property to the city, a new pumping engine from original designs was built by The A. Harkness Company of Cincinnati. This "power" as it was termed had a capacity of 3,000,000 gallons per day pumped from the Ohio River to a reservoir on the site of the old Third Street Reservoir. This reservoir, abandoned in 1907, supplied by gravity the district lying between Fourth Street and the river. The first two steam pumping engines installed by the water company (1824-1834), were vertical crank and fly wheel machines with the water ends

set low enough to take water by suction from the river at its lowest stages, and the steam ends placed high enough to be above all ordinary flood stages in the river. The maximum flood stage of record is more than 71 feet above low water mark, and it will thus be seen that the steam ends of these pioneer pumps must have been set about 50 feet above the water ends.

After the purchase of the works by the city a new duplex steam power was built (1844) which consisted of a pair of crank and fly wheel steamboat engines on inclined frames driving vertical pumps. These pumps had a combined capacity of 5,000,000 gallons per day and after various changes in the steam valve gear became and remained for years the most useful and economical machines in the Front Street Station. They were taken out of service during 1907 after sixty-three years of useful life.

Passing over the details of water works improvements under city management from the purchase in 1839 to 1865, we come to a period following the war of the states, when it was evident that the works were in need of a general and comprehensive rehabilitation. During this period the two original pumping engines were abandoned and their places taken by two vertical condensing crank and fly wheel steam pumping machines, each of 4,500,000 gallons capacity (1850-1854) constructed from designs of Mr. T. R. Scowden by The A. Harkness Company and Powell and Sons, of Cincinnati. These engines were marvels for their day and with some changes in the water ends continued in active service until the Front Street Pumping Station was abandoned (1907).

The Harkness engine ran therefore for over fifty-seven years and the Powell engine ran for over fifty-three years. These machines rarely gave trouble and were the real "standbys" for over a half century, and were capable of good service at the date of starting pumping from the new works at California (Cincinnati).

A new stone masonry reservoir on the site of the original wooden reservoir was constructed 1850-1853. The two divisions having a combined capacity of 5,500,000 gallons with a water depth of 20.50 feet.

In 1865 Mr. James P. Kirkwood of Brooklyn, New York, then the foremost water works engineer in America, was called to Cincinnati for the purpose of investigating and reporting on the requirements of the city for a new and enlarged water works and the possible adoption of a new source of water supply, many complaints

having been made before that date upon the unsatisfactory condition of the Ohio River water. Mr. Kirkwood began with an inquiry into the past and prospective population growth of the city and from the diagrams which he constructed he reached the conclusion that the population of the city in 1890 (twenty-five years ago) would be larger than it is at the present date. He made the same mistake that many others have made since his time, of assuming that the past will be an exact index of the future. It will be interesting and instructive to reproduce his population table and parallel it with the census reports to 1910.

Cincinnati Population

<i>Year</i>	<i>Census</i>	<i>Kirkwood, 1866, Prediction</i>	<i>Hill, 1896, Prediction</i>
1800.....	750		
1810.....	2,540		
1820.....	9,602		
1830.....	24,831		
1840.....	46,338		
1850.....	115,438		
1860.....	161,044		
1870.....	216,239	225,460	
1880.....	255,139	315,460	
1890.....	297,000	431,644	
1900.....	325,902		335,000
1910.....	364,463		370,000
	Estimated		
1915.....	400,000		385,000

In 1896 the Engineer Commission on Extension and Betterment of the City Water Works had occasion to study the probable growth of population in the city, including the growth in territory to be annexed, and the results from the curve then projected are given for the years shown.

By adding the neighboring cities in Kentucky and the suburbs in Hamilton County, Cincinnati has a population at the present time of nearly 550,000.

In projecting the capacity for a new water works Mr. Kirkwood assumed that the statistics of consumption for New York and Brooklyn would apply to Cincinnati, and adopted a per capita rate of 65 gallons, our consumption rate at present is about 130 gallons per capita, or twice Mr. Kirkwood's quantity.

"Mr. Kirkwood made a thorough survey and investigation of the various sources for a new water supply, and adopted a pumping system, continuing the Ohio River as a source. The site selected was about two miles above the present pumping works (1880), and the plan embraced two lifts, with subsiding and filtering reservoirs. The cost was placed at \$3,038,214.07."

"The plan was highly recommended by a majority of the water commissioners, but the minority report advocated retaining the pumping works, Front Street Station, and the construction of additional reservoirs. The latter plan was adopted, and the Garden of Eden purchased for reservoir and park purposes on 6th of January, 1866."

None of Mr. Kirkwood's recommendations were adopted, although his report shows a very thorough study of conditions as they existed, even to the necessity for subsidence and filtration of the Ohio River water before it was distributed to consumers. In Mr. Kirkwood's day not much was known of bacterial purification of water and his terms for a pure and wholesome water was that it should be "clear and colorless."

It may be of interest to note that the late Mr. J. J. R. Croess of New York was Mr. Kirkwood's principal assistant on the Cincinnati investigation.

Using plain sand filters and including the cost of settling basins of 84,000,000 gallons capacity, Mr. Kirkwood figures the cost of subsidence and filtration at \$18.50 per million gallons, including fixed charges on the construction cost. Omitting fixed charges on the subsiding basins and filters he estimated the operating and maintenance cost at \$1.37 per million gallons, or about the cost which he subsequently found abroad upon his visit to Europe, in 1866. Mr. Kirkwood's plans also provided for a storage reservoir of 152,000,000 gallons capacity for the subsided and filtered water.

The reservoir in Eden Park (Garden of Eden) consists of two divisions, one containing 43,000,000 gallons, and the other 57,000,000 gallons. The basin is constructed in a ravine of very steep channel and side slopes. The smaller division is closed at the lower end of the ravine by a massive retaining wall 120 feet high at the middle of the ravine. The division wall between the two compartments of the basin is 67½ feet high at the middle of the ravine. The water depth is 30 feet. The reservoir and walls were designed and in part built by Mr. Henry Earnshaw at that time superintendent of the city water works.

During 1872, or seven years after Mr. Kirkwood's investigation, the trustees of the water works entered into contract with a local company for two additional pumping engines, each of 7,500,000 gallons daily capacity. These engines were designed by Mr. Theodore R. Scowden, and were of the vertical crank and fly wheel direct acting type, with walking beams to connect the steam pistons to the cranks and fly wheels placed below the steam cylinders under the engine room floor.

The design of these engines was modern for non-condensing machines, and among other innovations were furnished with differential plunger pumps of the "Wright" type.

One difficulty always experienced with the Cincinnati pumping engines in the Front Street Station was due to the considerable vertical separation of the steam and water ends. The pumps were set on solid masonry foundations, while the steam cylinders and rotating parts were mounted on iron skeleton frames or towers, 50 or 60 feet high. An exception should be made of the Wetherill engines, which were erected on horizontal steel girders set in heavy masonry side walls. The Scowden engines were started in 1872-1874, and the Wetherill engines in 1885-1886.

Other engines were erected in the Front Street Pumping Station, viz.: the Shield Engine (1865) which was of the Cornish Bull condensing type with a steam cylinder 100 inches diameter by 12 feet stroke. The steam piston, air pump piston and pump piston were all mounted in line on a continuous rod over 55 feet long. The engine and pump never worked very successfully and the machine was so wasteful of fuel that it was never operated from choice. The expected capacity of this machine was 20,000,000 gallons per day, but it rarely worked above a 12,000,000 gallon rate. The engine was so untrustworthy that the attendants were never allowed to leave their respective stations while it was running.

The designer of the engine, Mr. George Shield, was the leading steam engineer of the city when he built this machine, and its failure as a safe, economical and useful unit of the power in the Front Street Station destroyed his reputation and was supposed to have shortened his life. No other engine of the Shield type was ever built either before or since. While it was patterned in part after the Cornish Bull engine and pump, the departures from the original type were sufficient to bring about substantial failure of the machine as a useful adjunct of the Pumping Station.

Two duplex vertical direct acting Worthington pumping engines were also erected in this station (1888), each of a rated capacity of 12,000,000 gallons per day. These engines never were very successful; indeed it was said that at no time in their history were both engines in condition to operate simultaneously, although it is well known that at critical periods everything at the Front Street Station that could lift water from the Ohio River was required in service.

Excepting the 20,000,000 gallons Shield engine, all others built from local designs by local builders were successful, the so-called combination (steamboat) engines, the Harkness and Powell engines, were in constant service for over fifty years, while the Scowden engines, also built in Cincinnati, ran successfully from 1872 until the station was abandoned December, 1907, a period of thirty-five years. The difficulty with the pumping engines designed and built in the East was that the designers failed to grasp the special necessities of pumping engines where the pumps were often submerged for days at a time in from 10 to 50 feet of water; where all sorts of trash would at times collect in the pump wells to interfere with the operation of pumps, and where the steam ends must be as simple and reliable as possible to avoid the stoppage of the power. Engines well adapted to a service where the entire machine could be at all times inspected while in operation, were not adapted to the Ohio River service and the troubles of which there were many within the writer's experience at the Front Street (River) Pumping Station have been experienced in other city water works on the Ohio River. It is thought that the rise and fall of the Ohio River at Cincinnati, 71 feet and $\frac{3}{4}$ inch, is the greatest in the world, and the pumping machinery as heretofore constructed with the connecting rods, links and fly wheels often wading many feet deep in the water presents a condition not paralleled in many other cities of the country, or even out of the country.

"In 1872 the city purchased a site from John Markley, ten miles above the city, for a new water works. The property embraces 146 acres, for which the sum of \$22,321.50 was paid."

"Mr. T. R. Scowden submitted plans and estimates for the new works to be located on these grounds, which embraced a pumping system with two lifts, subsiding and distributing reservoirs, and two 42-inch delivery mains, the whole to cost \$4,500,000."

Cincinnati is one of the few cities in the world requiring three pumping lifts to get water from the Ohio River to the consumers.

The difference of elevation between low water mark in the river and the highest territory supplied with water within the city limits being 507 feet. There are several states in the Union where the extreme variation of levels within their boundaries is not so great as that which occurs within the corporate limits of this city. Even with the three pumping lifts there are still some premises within the city limits at elevations not reached by the city water.

In 1871, Mr. Theodore R. Scowden was employed to investigate the water supply needs of the city and report upon a new source of supply and comprehensive improvement of the water works. Long previous to this date the people had realized that the water taken from the river at the Front Street Pumping Station was unsatisfactory in quality, and, with frequent breakdowns in the pumping machinery and no considerable storage, was often insufficient in quantity. At that time Eden Park Reservoir had not been constructed, nor had the Scowden engines previously mentioned been installed, so that with only the limited storage in Third Street Reservoir, 5,500,000 gallons, and a total pumping capacity of 14,000,000 gallons for a population of over 220,000, the conditions were on the whole not very promising.

Mr. Scowden before this date had the honor of planning the water works of Cleveland, Louisville and Newport, Kentucky, and was the ranking engineer in Cincinnati in this line of work, and enjoyed a reputation for skill and judgment which was unquestioned by his associates in the profession. But as in the case of Mr. Kirkwood, six years before, his plans and recommendations were set aside, and all that came of his work was the purchase of Markley Farm, and the construction of two new pumping engines previously mentioned. Eden Park Reservoir at that time was under construction, and the sole outcome of Mr. Scowden's very thorough surveys and comprehensive plans was an addition of 15,000,000 gallons to the pumping capacity of the Front Street Station.

Mr. Scowden's plans embraced the location of a source of water supply from the river about ten miles up stream from the Front Street Station, a new pumping station, new modern and ample low and high lift pumping machinery, subsiding reservoirs on the river bank, and a storage basin of 300,000,000 gallons capacity at an elevation sufficient to supply by gravity to Eden Park Reservoir, from which latter when completed, distribution to the city would be made. He also considered the ultimate filtration of the

water and allotted space on the land purchase for the location of filters. The land for the entire works was known as the "Markley Farm purchase," which aside from the rent collected from the farmers through a period of about thirty-six years has been of no benefit to the city. The farm was finally sold upon completion of the new water works improvement, 1907-1908.

During 1885-1886 the Wetherill engines each of 10,000,000 gallons daily capacity were installed in the Front Street Pumping Station, and at later dates as noted 1887-1888 two additional Worthington engines were installed. Meanwhile Eden Park Reservoir was completed and this with the Front Street Station and Third Street Reservoir constituted the primary pumping, subsiding and storage elements of the city water works.

Like the proverbial "poor" mentioned in Scripture, the evils of the source of supply, inadequate and antiquated pumping machinery, old fashion steam boilers, and limited storage of water, were always with us. Apparently since the days of Samuel W. Davies the city had not caught up with the demands and requirements of the people. The press and scientific bodies were constantly pointing to defects and insufficiencies in the public water works and demanding a remedy. Laws were enacted by the legislature to provide for a new enlarged and adequate water supply system, votes were taken and through the friction and jealousies of politics, such measures were disapproved at the polls.

During 1895 by the joint investigations of Hon. August Herrmann, afterwards president of the board of commissioners of water works, the writer and one other, it was discovered that an enabling act might be passed by the legislature which would permit the building of a new water works without submitting the matter to a vote of the electors, because it had been shown through a period of nearly seventy years that however much the public was dissatisfied with the existing condition of things it would not by its vote authorize a substantial change. All the additions of pumping engines, reservoirs and pipes since the purchase of the water works in 1839 had been provided for from the revenues of the water works and not by popular bond issues.

After several years of investigation and careful inquiry into the legal status, it was decided in 1895 to proceed upon an investigation, preparation of plans and estimates of costs, and the framing of a law which would permit the city to construct a water works

commensurate with the growth of population and increased demand of the people. Accordingly the city board of administration during December, 1895, appointed a commission of engineers, consisting of the writer, Mr. Samuel Whinery, now of New York, and Mr. George H. Benzenberg of Milwaukee, to conduct an investigation, make surveys, examine water sources and report plans and estimates of cost for the extension and betterment of the city water works. This commission reported March, 1896, upon a general plan for improvement of the water works, which with some necessary changes furnished the foundation upon which the late improvements of the city water works are based.

Cincinnati has today in point of pumping machinery, methods of handling and storing coal, subsidence reservoirs, filtration works, and distribution system, a works not surpassed by any city in or out of the country, and since the members of the Association will have the opportunity of inspecting the details of the work at this Convention, May, 1915, and forming their own opinion of their merits, it is deemed advisable to say no more at this time about them.

In preparing this brief memoir on the history of the Cincinnati Water Works, credit must be given to the late Mr. E. M. Shield, and to the late Mr. Charles Cist, and to Mr. Thomas J. Bell, and others who have formerly written on the subject from which the information herein given has been largely drawn. The development of the Cincinnati Water Works has received the earnest and profound thought and efforts of some of the most distinguished members of the engineering profession, and while some of these have not realized the fruition of their individual ideas, yet each has been an influence in bringing about the ultimate happy result.

WATER ANALYSIS AND THE NITROGEN CONTENT OF WATER

BY WILLIAM M. BOOTH

All available scientific data, both chemical and bacteriological, should be collected and studied before judgment is passed on a water supply used for food, and such should be systematically recorded by all water works companies.

The nitrogen content of water and the chemical conditions in which this is found have long been considered very valuable, nor is there at present any good reason to discredit the use of such reports.

All sanitarians are familiar with the gradual change of animal and plant nitrogen in the combined form until it reaches the inorganic nitric state, and the chemical changes will not be further discussed than to remark that unpolluted natural waters, with few exceptions, are remarkably free from nitrogen. The analyses¹ are recorded to show how the waters of central New York differ in nitrogen content and in what state this element has been found. All tests have been made according to the methods prescribed by Wanklyn and Mason and are tabulated in parts per million. The total solids determination is the weighed residue from 50 cc. of water, evaporated to dryness on the water bath and placed in a desiccator over sulphuric acid for twelve hours. Chlorine has been determined volumetrically, according to Mason, unless above 50 parts per million, when the gravimetric method was employed. Free and

¹ This paper is a supplement to a paper in the September, 1914, *Journal*, The Use of Nitrate Test in Determining Source of Pollution of a Water Supply, and is intended to correct errors in printing the 1914 paper. The following typographical errors are also noted in the paper in the September *Journal*:

On page 602, first line of second paragraph, read Fig. 2.

Page 602, last line for No. 2 read No. 53.

Page 604, sixth line of first paragraph for No. 4 read No. 55.

Page 606, table heading eighth column read Oxygen consumed and ninth column read Colonies per cc.

Page 609, Nos. 124-126 for New Syracuse read Near Syracuse.

albuminoid ammonia are determined separately, and a check has been made in each instance by estimating the total ammonia in another sample. If this form of nitrogen is known to be unusually high, as in the case of sewage, 10 or 100 cc. are diluted with ammonia free water and are distilled as an original sample, using a proper dilution factor. The nitrates and nitrites are determined according to the Mason method and were made in duplicate using freshly prepared standard solutions. The "oxygen consumed" test is made according to the Mason method. All results shown are the work of the writer unless credited to others. The bacteriological analyses were made by the bacteriologist of the city of Syracuse.

Turning now to the analytical tables (p. 606, vol. 1, no. 3, September, 1914, *Journal*) analyses 1 to 7 inclusive show that rain, snow, ice and distilled water may contain free ammonia, albuminoid ammonia, nitrates and nitrites.

Analyses 22 to 26 inclusive show the absence of nitrites in Syracuse city water beginning at the upper or south end of Skaneateles lake, about 32 miles from the city, and at various points in its progress to the city, with a final analysis in a downtown city block. The water shed has an area of about 74 square miles and nitrites are seldom found in this water. Such sometimes occur in November and during the latter part of March. During the past ten years, the writer has never detected more than 0.002 parts per million. The overflow from the lake becomes the source of power for several mills and contains the sewage from the villages along the stream. The nitrogen in this water is shown in analyses 27 to 30 inclusive. Paper, felts, and woolen cloth are manufactured.

Onondaga creek is a country stream that enters the city of Syracuse at the south end. It is, at present, an open sewer and enters Onondaga lake with a fall through the city of about 40 feet. Analysis 8 was made from a sample taken from the creek as it enters the city, and number 9 shows the nitrogen condition of the water as it enters the lake.

Numbers 9 to 17 inclusive were made at about equal distances through the length of Onondaga Lake, which is five miles long. This lake is the sewage outlet for the city of Syracuse, the town of Solvay and the village of Liverpool. The waters of the lake are naturally very salt. A high nitrite content throughout shows a very unstable condition from a nitrogen standpoint. The Seneca River analysis No. 20 was made at the junction and the large decrease

in salt roughly indicates the degree of dilution, as the river water is not unusually high in chlorine.

Number 21 is the analysis of a sewer water from the city that enters the lake.

At its mouth Onondaga Creek has a nauseating odor and contains suspended solids. At the Seneca River junction, the samples taken were free from odor and contained practically no suspended solids.

Numbers 38 to 40 inclusive are tests of Lake Ontario water, and were made to show the efficiency of the mechanical filtration plant of the Rochester and Lake Ontario Water Company at Charlotte.

Number 42 is the analysis of Hemlock Lake water which is the main supply of the city of Rochester. It is now used in conjunction with the purified water from Lake Ontario. Both sources of supply are considered excellent and the total nitrogen content is low.

Number 41 is an analysis of unfiltered Niagara River water, used in the city of Lockport.

Numbers 80 to 83 show that the supply of the city of Fulton is a composite water. The Great Bear Spring has no connection with the well known water of that name. Just west of Fulton there is a lake, the water of which is used for manufacturing purposes in the city. The outlet is low and sluggish, and analysis 31 shows the condition of the water at this point. After use in manufacturing, the increase in nitrogen is shown in numbers 32 to 37 inclusive. The latter is undiluted factory waste.

The village of Seneca Falls (see map in September, 1914 *Journal*) is supplied by water from Cayuga Lake just above the northern outlet. At this point the lake is shallow; many cottages are located on the western bank, and the village of Cayuga lies opposite. Although 40 miles in length and, at points, several hundred feet in depth, a number of large towns sewer directly into this lake, and nitrites are normally present in samples taken from the outlet, especially after the summer season. To determine the condition of the water at the north end of the lake, analyses 43 to 51 were made. The writer testified that the nitrites found in this water showed pollution too serious to admit of its use in the raw state, while several well known experts declared that the water was entirely potable. However, a mechanical filtration plant has been installed by order of the state Board of Health.

Numbers 92 to 95 inclusive are analyses of new wells, driven

in low ground beside the Clyde River. Employees drank this water for a short time, but were physically inconvenienced and another source was substituted.

Numbers 96 to 100 inclusive are analyses made after seven deaths from typhoid fever, supposed to have been caused by impure water, at a club house in the Adirondacks. The location, on the banks of a river, was formerly ideal, but the waters of the stream were dammed by the state at a point several miles below, and the banks overflowed for miles. The water was made stagnant and trees were killed on both banks. Presumably the sewage contaminated the wells which were driven in sand. A new source was secured on higher ground, a septic tank was built, and no severe sickness from water has occurred since.

The remaining analyses have been taken from miscellaneous records, and are explained in the margin. Numbers 101 and 102 are particularly interesting, as the highest nitrate nitrogen recorded in the list was found at this point. After the barn had been turned into a garage, the well became available as a potable water supply.

Numbers 103, 104, and 105 show how a new well furnishes water of varying quality. This well was pumped continuously from September to December, by means of an air lift.

Number 106 is extraordinarily high in nitrites.

The above analyses show the nitrogen content of some central New York waters, and from them the writer draws the following conclusions:

Many natural waters of this area contain nitrogen in all of the forms reported in the analytical scheme.

Water containing sewage is in a highly unstable condition as regards the form in which nitrogen is found.

Records should be kept showing the nitrogen content of potable waters, and weekly, if possible daily, tests should be made.

No quantitative relationship exists between the nitrogen of water and the bacteriological content.

The presence of nitrites in water ordinarily free from this form of nitrogen must be regarded with suspicion.

If nitrates are present in water above one part per million, it may have an unhealthy source.

A SPECIAL WATER STANDARD

BY W. F. MONFORT

The adoption by the treasury department of a bacteriological standard for drinking water supplied by common carriers in interstate commerce marks a further advance in public sanitation. The sanitary drinking cup has been in evidence on trains for several years in most states, and measures intended to protect the traveling public against infection have been enforced with various degrees of success. The compression cock still invites carelessness. The irresponsible passenger still drinks from the faucet instead of from "an envelope." The education of the entire traveling public to habitual regard of sanitary precautions is a slow process. The most flagrant offender, the employee, who mixes good or bad water with ice of doubtful origin and worse history, is the real object of attack in the campaign for which this special standard affords a basis. Within the past few months regulations have been made effective forbidding direct icing of water on lake steamers. Thus far no order has been issued as to railroads.

The State Board of Health of Kansas issued an order that after July 1, 1913, ice must not come in contact with drinking water as supplied on trains or provided in railway stations. Many stations in France which possess the requisite supply of electricity are provided with sterilizing apparatus for providing a safe supply. The practice has been growing since 1913. Whatever solution of a difficult problem may be adopted by railway officials in this country, the establishment of a standard of quality is an important step.

The standard adopted was in accordance with the conclusion of a commission of fifteen men prominent in sanitary science appointed in January, 1913, by the surgeon general of the United States, "to recommend standards of purity." It is significant that after almost two years' consideration, they have made a progress report covering "the maximum limits of permissible bacteriological contamination," deferring as more involved the question of limits of permissible impurities other than bacteriological. The Commission evidently

experienced the very serious difficulty, well stated by Mr. George A. Johnson in his paper before the 1913 convention of this Association, of correlating the fitness of a water for drinking purposes with definite numerical data as to turbidity, color and specific dissolved mineral matter. The problem in this instance is complicated by the extremes of mineral and physical characteristics which occur from the soft waters of New England to the alkaline supplies of the southwest.

It would not appear difficult to arrive at permissible limits for lead, copper and iron due to contact with containers. The Commission has probably preferred to withhold any conclusions it may have reached with respect to chemical and physical properties until this portion of its report should be presented in entirety.

It is emphatically stated that these limits of impurity are established for drinking water in specific conditions where judgment must be based on laboratory work only, without the possibility of knowledge derivable from a survey of its source or from repeated examinations.

The bacteriological standard recommended for this special class of waters will meet with unreserved approval generally.

1. The agar count at 37°C. for 24 hours shall not exceed 100 per cubic centimeter.

2. Not more than one out of five 10 cc. portions of any sample examined shall show the presence of organisms of the bacillus coli group, which for the purpose of this standard includes all aerobic, acid forming, lactose fermenting organisms.

The routine of examination has been simplified as much as possible, using only plain agar, lactose broth and litmus-lactose-agar or Endo's medium, and embodies the familiar work of several members of the Commission in developing and perfecting discriminations by these simple media. The full text of the report, which may be had as Reprint No. 232 from *Public Health Reports*, is of interest to every member of this Association.

BACTERIOLOGICAL STANDARD FOR DRINKING WATER¹THE STANDARD ADOPTED BY THE TREASURY DEPARTMENT FOR DRINKING
WATER SUPPLIED TO THE PUBLIC BY COMMON CARRIERS IN INTERSTATE
COMMERCE²

The standard is one recommended by a commission appointed for the purpose by the Secretary of the Treasury January 22, 1913. The commission was composed of the following members:

John F. Anderson, Director Hygienic Laboratory, chairman of the commission, Washington, D. C.

Edward Bartow, Director, Illinois Water Survey, Urbana, Ill.

Charles C. Bass, Director, Laboratory of Clinical Medicine, Tulane University, New Orleans, La.

S. J. Crumbine, Secretary State Board of Health, Topeka, Kans.

Edward C. Franklin, Professor of Chemistry, Leland Stanford Junior University, Stanford University, Cal.

Henry Hanson, Bacteriologist, State Board of Health, Jacksonville, Fla.

Charles Gilman Hyde, Professor of Sanitary Engineering, University of California, Berkeley, Cal.

Edwin O. Jordan, Professor of Bacteriology, University of Chicago, Chicago, Ill.

Allan J. McLaughlin, Surgeon, Public Health Service, Washington, D. C.

William H. Park, Director, Research Laboratories, Department of Health, New York City.

Milton J. Rosenau, Professor of Preventive Medicine and Hygiene, Harvard University, Cambridge, Mass.

William T. Sedgwick, Professor of Biology, Massachusetts Institute of Technology, Boston, Mass.

George C. Whipple, Professor of Sanitary Engineering, Harvard University, Cambridge, Mass.

C. E. A. Winslow, Curator, Department of Public Health, American Museum of Natural History, New York City.

Wade H. Frost, Passed Assistant Surgeon, Public Health Service, recorder of the commission, Washington, D. C.

THE BACTERIOLOGICAL STANDARD FOR WATER

The following are the maximum limits of permissible bacteriological impurity:

1. The total number of bacteria developing on standard agar plates, incubated 24 hours at 37 degrees C., shall not exceed 100 per cubic centimeter. Provided, that the estimate shall be made from not less than two plates, showing such numbers and distribution of colonies as to indicate that the estimate is reliable and accurate.

¹ For the benefit of those members who have not had copies of the Government Document the standard is reproduced here in full.—EDITOR.

² Reprint from the *Public Health Reports*, vol. 29, No. 45, Nov. 6, 1914.

2. Not more than one out of five 10 cc. portions of any sample examined shall show the presence of organisms of the bacillus coli group when tested as follows:

(a) Five 10 cc. portions of each sample tested shall be planted, each in a fermentation tube containing not less than 30 cc. of lactose peptone broth. These shall be incubated 48 hours at 37 degrees C. and observed to note gas formation.

(b) From each tube showing gas, more than 5 per cent of the closed arm of fermentation tube, plates shall be made after 48 hours' incubation, upon lactose litmus agar or Endo's medium.

(c) When plate colonies resembling *B. coli* develop upon either of these plate media within 24 hours, a well-isolated characteristic colony shall be fished and transplanted into a lactose-broth fermentation tube, which shall be incubated at 37 degrees C. for 48 hours.

For the purposes of enforcing any regulations which may be based upon these recommendations the following may be considered sufficient evidence of the presence of organisms of the *Bacillus coli* group.

Formation of gas in fermentation tube containing original sample of water (a).

Development of acid-forming colonies on lactose litmus agar plates or bright red colonies on Endo's medium plates, when plates are prepared as directed above under (b).

The formation of gas, occupying 10 per cent or more of closed arm of fermentation tube, in lactose peptone broth fermentation tube inoculated with colony fished from 24-hour lactose litmus agar or Endo's medium plate.

These steps are selected with reference to demonstrating the presence on the samples examined of aerobic lactose-fermenting organisms.

3. It is recommended, as a routine procedure, that in addition to five 10 cc. portions, one 1 cc. portion, and one 0.1 cc. portion of each sample examined be planted in a lactose peptone broth fermentation tube, in order to demonstrate more fully the extent of pollution in grossly polluted samples.

4. It is recommended that in the above-designated tests the culture media and methods used shall be in accordance with the specifications of the committee on standard methods of water analysis of the American Public Health Association, as set forth in *Standard Methods of Water Analysis* (A. P. H. A., 1912).

The standard as recommended by the commission was submitted with the following report discussing the question of standards of purity for water in general:

First Progress Report of Commission Appointed to Recommend Standards of Purity for Drinking Water Supplied to the Public by Common Carriers Engaged in Interstate Traffic.

LIMITS OF PERMISSIBLE BACTERIOLOGICAL CONTAMINATION

More than a year has been devoted to consideration and discussion of the problems raised in this connection; but, since the discussion has of neces-

sity been conducted solely through correspondence, progress has inevitably been slow, so that, even after so long a time, there remain a number of questions upon which satisfactory agreement has not yet been reached. Your commission, not wishing, on the one hand, to curtail free discussion of points upon which satisfactory agreement has not been reached, nor, on the other hand, to further delay submitting such recommendations as have been agreed upon, respectfully request that this report, though incomplete, be accepted and utilized pending the rendering of a more complete report dealing with questions not included herein.

As a preface to the recommendations which follow it is desired that a clear distinction be made between "standards of purity" and "limits of permissible impurity." Since purity is an absolute, not a relative, quality, it is obvious that there can be no "standard of purity" other than absolute purity; that this must be the point of departure in estimating deviations from purity or degree of impurity. The recommendations here presented are limits of permissible impurity; they are in no sense "standards of purity." They are recommended not as the nearest approximation to purity which it is desirable to attain; but, on the contrary, as the furthest deviations from purity considered permissible on the water supplies with which this report deals. In this connection it is desired also to emphasize the statement that these limits of impurity are recommended only for application to the special case in question; that is, the control of the sanitary quality of the water supplies of common carriers.

The problem before the commission has been to recommend limits of permissible impurities such as to meet the following requirements:

1. That water supplies conforming to the prescribed requirements shall be free from injurious effects upon the human body and free from offensiveness to the sense of sight, taste, or smell.

2. That supplies of the quality required shall be obtainable by common carriers without prohibitive expense.

3. That the examinations necessary to determine whether a given water supply meets the requirements shall be as few and as simple as consistent with the end in view.

In the attempt to establish limits of this kind it has been inevitable that manifold difficulties should have been encountered. The first of these is the difficulty inherent in any attempt to establish an exact line of demarcation between two such extremes as undoubtedly safe water supplies and those which should assuredly be condemned. This difficulty is enhanced by the necessity of defining uniform limits for waters from such diverse sources and subject to such varied conditions of storage as are the supplies of common carriers, and is still further enhanced by the necessity of limiting to a practicable minimum the number and kind of examinations upon which judgment must be formed. It is a fact so well established as to need no further discussion that the results of bacteriological and chemical examination of a sample of water ought always to be correlated with a knowledge of the source, treatment, and storage of the supply in order to enable a just estimate of the sanitary quality of such supply. With a full appreciation of this fact it is, nevertheless, necessary for our purpose to define limits based solely on the

results of laboratory examinations, since it is often in practice impracticable to obtain first-hand authoritative information regarding the source and handling of the supplies of common carriers as actually distributed to the public. The effect of eliminating a portion of the desirable information is to necessitate somewhat more liberal limits for permissible amounts of impurities which are not actually and definitely injurious and which are removable only at great cost, and narrower limits for permissible impurities of definitely dangerous character.

In regard to the physical and chemical properties which render water disagreeable to sight, taste, or smell without producing any concrete harmful effect a difficulty is encountered in that the degree of offensiveness is not accurately measurable, being largely dependent upon individual taste and habits. Again, regarding many of the constituents found in natural waters, as, for example, various mineral salts, it is impossible in the present state of our knowledge to definitely specify the ill effects, if any, which given amounts of these substances may produce. Limits upon these impurities must, accordingly, be so placed as to allow the public an ample margin of safety; but to do this raises the question as to how far it is justifiable to tax the carriers to eliminate impurities whose deleterious effects are so doubtful. This question is the more difficult since it is generally impracticable to remove the mineral salts present in waters by measures of practicable application, and consequently narrow limits to the permissible amounts of such substances will have the effect of eliminating many sources of supply—sources which will frequently be the only ones readily available and may yield waters conforming with entire satisfaction to the other more important sanitary requirements. Finally it is in regard to permissible amounts of mineral constituents that the greatest difficulty is encountered in framing such requirements as shall require only simple methods of examination for their enforcement.

It is because of these difficulties and because of the minor sanitary importance of regulating the chemical impurities of water supplies that these questions have been left for further discussion and this report drafted to deal only with the more important question of regulating bacteriological impurities.

The definition of limits for the permissible bacteriological pollution of the water supplies in question is at once more important and simpler than defining limits for permissible chemical impurities. It is more important because the most dangerous of all the impurities which may be present in drinking water are disease-producing bacteria and other parasitic disease germs. It is simpler than the other problems mentioned, because as the result of a vast deal of careful study which has been devoted to the bacteriological quality of water supplies and their effects upon the public health it is now possible to define with reasonable precision what constitutes a bacteriologically safe water supply. Finally, strict regulations, requiring common carriers to provide water of undoubtedly safe bacteriological quality, are thoroughly justified, because where water of the requisite degree of purity is not obtainable from a convenient natural source, it is entirely practicable to obtain a pure supply from a moderately polluted source by comparatively simple and inexpensive processes of purification. The art of water purifi-

cation has, in fact, progressed to the point where there is no longer any excuse whatsoever for using bacteriologically polluted water.

The vast majority of the bacteria found in drinking water supplies are entirely harmless, and regulations designed to insure freedom from disease-producing bacteria must, accordingly, be concerned more with the character than the numbers of the bacteria present. The isolation of the disease-producing bacteria which may be present even in highly polluted waters is so nearly impossible, because of the difficulty of separating them from the much more numerous harmless bacteria with which they are associated, that in actual practice the attempt to directly demonstrate the presence of disease-producing bacteria is seldom made. The bacteriological examination of water supplies has therefore been developed, rather, along the line of determining the number and proportion of certain broad classes of bacteria present in a given volume of water, namely:

1. Bacteria developing distinct colonies within 48 hours at 20 degrees C. on standard gelatin culture medium.
2. Bacteria which developed distinct colonies within 24 hours at 37 degrees C. on standard agar culture medium.
3. Bacteria belonging to the *Bacillus coli* group.

It is beyond the scope of this report to enter into a detailed discussion of the interpretation of results of bacteriological examination of water supplies. In general, reliable interpretations can be made only by those having a sufficiently broad knowledge of bacteriology to enable them to apply the established general principles to each case as it is presented.

The bacteria developing on standard gelatin at 20 degrees C. include a relatively large proportion of harmless bacteria which are normally inhabitants of soils and natural waters free from dangerous pollution. The number of bacteria, as estimated by the standard gelatin count, serves in a general way as an index of the cleanliness of the sample; but to properly interpret the results of such a count it is necessary to have knowledge of the source of the sample examined, the nature of the pollution to which it has been exposed, and the opportunities afforded for multiplication of the harmless varieties of bacteria present. On account of the rapid multiplication of harmless varieties of bacteria, which may take place when water is stored in small containers at moderate temperatures, and the impossibility of making approximately correct allowance for such multiplication, it is believed that the attempt to establish a limit for bacteria developing on gelatin is not practicable for the purposes of the control of supplies of common carriers.

The bacteria developing on standard agar at 37 degrees C. in 24 hours are also chiefly varieties which are entirely harmless. The agar count, however, as compared with the gelatin count, represents a larger proportion of bacteria which find their normal habitat in the animal body and are present in sewage and other discharges from the animal body. Generally speaking, an excessive agar count is sufficient to cause at least a suspicion that the water is polluted with discharges from the animal body, and is therefore unsafe for use as drinking water. Multiplication of the harmless varieties present may, however, take place at ordinary temperatures in water stored in tanks, coolers, bottles, and other containers, thus greatly increasing the agar count,

without, of course, increasing the actual dangerous pollution of the water. This introduces a large source of error into the attempt to interpret the significance of agar counts of samples of waters stored for varying lengths of time under conditions more or less favorable to bacterial multiplication. It is largely for this reason that it has been considered necessary to allow very liberal limits to the agar count of the water supplies of common carriers, and to attach to the results of this method of examination a significance much less than ordinarily attaches to the agar count in examining samples of water freshly removed from known sources.

Bacteria of the *Bacillus coli* group are normally inhabitants of the intestinal tract of warm-blooded animals, and it is believed that under ordinary conditions they do not multiply, in nature, outside of the animal body; that in drinking water supplies they tend, on the contrary, to die out rather rapidly. The presence of such bacteria in water may accordingly be considered valid evidence that the water has been polluted with the intestinal discharges of some of the higher animals and the numbers present may be considered a fair index of the extent of such pollution. Since practically all of the diseases which are known to be commonly transmitted through water supplies are due to germs which are discharged from the intestines of infected persons, pollution with intestinal discharges is not only the most offensive but by far the most dangerous kind of pollution to which water supplies are exposed.

It is obviously desirable that drinking waters should be at all times entirely free from such offensive and dangerous pollution, but it would be both impracticable and unnecessary to enforce a requirement that the supplies of common carriers should always be entirely free from bacteria of the *Bacillus coli* group. The test is an extremely delicate one, showing traces of pollution not detectable by any other means; all surface waters are naturally subject to more or less pollution with animal excreta, and experience has shown that efficient purification, rendering originally polluted waters entirely safe and satisfactory, never extends to the point of constantly and entirely removing all bacteria of the *Bacillus coli* group.

The limits recommended for permissible pollution of this character are as rigid as it is possible to make them without, on the one hand, requiring absolute freedom from such bacteria or, on the other hand, increasing materially the cumbersomeness of the examinations necessary to ascertain compliance with the requirements. Compliance with the requirements herein recommended will insure a quality of water supplies equal to that of municipal supplies which have been demonstrated by experience to be entirely safe and satisfactory and will at the same time impose no great burden upon common carriers, since it is entirely practicable, with moderate expense and pains, to purify water to the degree required.

In submitting the recommendations herewith presented it may be again emphasized that the limits defined are recommended with reference solely to the special object of the control of the supplies of common carriers, having in mind that these supplies constitute a special case because of the following reasons:

1. The supplies come from widely diversified and mixed sources.

2. Samples taken from common carriers represent waters stored for various lengths of time under varying conditions.

3. In view of the impossibility of accurately ascertaining the source and history of each supply examined reliance must be placed upon results of laboratory examination to a greater extent than is necessary or justified in estimating the quality of a supply from a known source with a known history.

It is requested that the recommendation of these hard-and-fast limits of bacteriological impurity be not interpreted as minimizing in any way the importance of field surveys in estimating the sanitary quality of water supplies in general. It is always desirable to obtain information from as many angles as possible, and this is, indeed, necessary in order to form an altogether fair estimate of an individual supply.

Pending the preparation of the report recommending specific limits for permissible chemical impurities, it is recommended that water supplies which may be bacteriologically sanitary be excluded from use when, in the opinion of the Surgeon General, they are definitely injurious to health or grossly offensive by reason of chemical impurities or physical properties.

EXAMINATION OF DRINKING WATER ON RAILWAY TRAINS

BY EDWARD BARTOW, PH.D.

In order to determine the character of water furnished to the passengers on railway trains, 100 samples from water containers on trains have been collected and analyzed by members of the staff of the Illinois State Water Survey. Although the number of samples examined is small, the information obtained concerning the actual condition of the waters should be valuable in formulating practical standards. The samples were secured from trains at Champaign, Urbana, Kankakee and Chicago. It was thus possible to secure samples from cars coming from all parts of the country: from Boston, New York and other points in the East; Jacksonville, New Orleans and Galveston in the South; San Francisco, Los Angeles and Denver in the West; Minneapolis, Duluth, Sault St. Marie in the North. The water is usually a mixture from several sources. It was impossible to learn the points from which all the water had been taken, but with five exceptions the table indicates the points at which the tanks were last filled.

Of the 101 samples, 28 of the tanks were said to have been last filled at Chicago, 9 at Peoria, 8 at Centralia, 6 at Detroit, 5 at Cincinnati, 4 at Indianapolis, 3 at Kansas City, Missouri; 2 each at Memphis, Tennessee; Salamanca, New York; and New York City; 1 each at Boston, Massachusetts; Buffalo, New York; Champaign, Illinois; Dubuque, Iowa, Effingham, Illinois; Forrest, Illinois; Ft. Madison, Iowa; Ft. Wayne, Indiana; Grand Rapids, Michigan; Havana, Illinois; Lincoln, Nebraska; Mason City, Iowa; Mattoon, Illinois; Minneapolis, Minnesota; Montreal, Province of Quebec; Nashville, Tennessee; Parsons, Kansas; Pittsburgh, Pennsylvania; St. Louis, Missouri; St. Paul, Minnesota; Sioux City, Iowa; South Bend, Indiana; Springfield, Illinois; 4 were bottled water from Hammond, Louisiana, and 1 bottled water from Waukesha, Wisconsin, and unknown 5. The majority of samples, 57, were taken from coaches, 19 from sleepers, 8 from dining cars, 7 from smoking

cars, 6 from parlor cars, 2 from tourist sleepers, and of 3 there was no record.

The analyses include both bacteriological and chemical examinations and an attempt has been made to make them as complete as possible when using 120 cc. samples for bacterial examination and 1 liter samples for the chemical tests.

METHODS OF ANALYSIS

The analyses have been made as far as possible in accordance with Standard Methods of Water Analysis of the American Public Health Association (1912) and all analyses made after May 1 include confirmations of *B. coli*, made in accordance with the recommendations of the Commission on Standards for Common Carriers in Interstate Commerce.

For method of determining *Turbidity*, see Standard Methods, page 55. *Color*, Standard Methods, page 8. *Odor*, Standard Methods, page 8. *Residue*, Standard Methods, page 30; but before weighing the residue was heated in an oven for one hour at 180°. *Chlorine*, Standard Methods, page 42.

Magnesium. Neutralize 100 cc. of the water with $\frac{N}{50}$ sulphuric acid using methyl orange as indicator. Boil to expel carbon dioxide. Add 25 cc. of a saturated solution of lime water. Dilute to exactly 200 cc. with boiled distilled water. Cool and filter through a dry filter paper, rejecting the first 25 cc., titrate 50 cc. with $\frac{N}{50}$ sulphuric acid using methyl orange as indicator. Make a parallel determination using 100 cc. of pure distilled water. The number of cubic centimeters of $\frac{N}{50}$ acid required for the distilled water, minus the number of cubic centimeters of $\frac{N}{50}$ acid required for the sample times 9.6 equals parts per million of magnesium (Mg).

Alkalinity. Titrate 100 cc. of the water in a 200 cc. flask with $\frac{N}{50}$ sulphuric acid using first phenolphthalein and then methyl orange as indicators. The number of cubic centimeters of $\frac{N}{50}$ acid required times 10 equals parts per million of alkalinity in terms of CaCO_3 .

Hardness. To the 100 cc. neutralized in determining alkalinity, add 10 cc. of soda reagent, a mixture of equal parts of approximately $\frac{N}{10}$ sodium hydroxide and $\frac{N}{10}$ sodium carbonate. Dilute with distilled water to exactly 200 cc. Allow to filter through dry filter paper rejecting the first 25 cc. and titrate 50 cc. of the filtrate with $\frac{N}{50}$ sulphuric acid to the methyl orange endpoint. Make a parallel

TABLE I
Analyses of water taken from railway trains

SAMPLE NO.	DATE OF COLLECTION	COLLECTOR	CITY	RAILROAD	TRAIN NO.	CAR	TANK FILLED AT	TURBIDITY	COLOR	ODOR	RESIDUE	CHLORINE	ALKALINITY	IRON	BACTERIAL COUNT		B. COLI IN LACTOSE BROTH SPECIAL 10 CO.
															Gelatin	Agar	
	1913																
1	Dec. 29	H.*	Champaign	I. C.	2	Diner	Hammond, La.	† 2	0	0	182	3	960.3	30,000	8,000		5-
2	Dec. 29	H.	Champaign	I. C.	2	Coach 28	Memphis	0	0	0	19	0	120.0	280	14		5-
3	Dec. 29	H.	Champaign	I. C.	2	Coach 3127	Centralia	1	0	0	344	23	920.0	187	5		3-2+
4	Dec. 30	H.	Champaign	I. T. S.		Coach		1	0	0	18	0	100.0	125	18		5-
5	Dec. 30	H.	Champaign	Big 4	16	Coach 644	Peoria	3	0	0	80	27	200.0		13		3-2+
6	Dec. 30	H.	Champaign	Wabash	36	Smoker	Champaign	8	20	0	426	0	350.0	10,000	1,500		5-
7	Dec. 31	H.	Champaign	I. C.	1	Diner	Hammond, La.	† 2	0	0	191	4	90.0	16,000	10,000		1-4+
8	Dec. 31	H.	Champaign	I. C.	1	Sleeper	Chicago	15	20	0	147	1	940.4	1,500	510		2-3+
9	Dec. 31	H.	Champaign	I. C.	1	Coach 2109	Chicago	10	5	0	159	3	960.0	54	23		5-
	1914																
10	Jan. 5	T.	Champaign	I. C.	1	Diner	Hammond, La.	† 2	0	0	205	10	1000.3	1	4		5-
11	Jan. 5	T.	Champaign	I. C.	1	Coach	Chicago	5	0	0	357	50	760.0	600	61		2-3+
12	Jan. 5	T.	Champaign	I. C.	1	Coach	Chicago	20	5	0	170	3	1080.1	90	36		2-3+
13	Jan. 5	T.	Champaign	I. C.	24	Smoker	Centralia	3	0	0	148	32	280.0	20	15		4-1+
14	Jan. 5	T.	Champaign	I. C.	24	Coach	Centralia	0	0	0	42	2	260.0	160	75		5-
15	Jan. 5	T.	Champaign	I. C.	24	Coach	Effingham	0	0	0	150	12	840.0	61	24		5-
16	Jan. 5	H.	Kankakee	C. I. & S.		Coach	South Bend, Ind.	0	0	0	331	10	2160.0	140	30		5-
17	Jan. 7	T.	Champaign	Big 4	16	Coach	Peoria	7	3	0	526	22	2682.5	36	14		5-
18	Jan. 7	T.	Champaign	Big 4	16	Coach	Peoria	7	0	0	524	2	2600.0	52	19		4-1+
19	Jan. 12	M.	Chicago	I. C.	18	Buffet	Springfield	5	5	0	43	8	82.0	60	13		5-
20	Jan. 12	M.	Chicago	I. C.	18	Sleeper	Parsons, Kan.	0	0	0	29	8	120.0	140	200		5-
21	Jan. 12	M.	Chicago	Big 4	31	Parlor car	Cincinnati, O.	5	0	0	25	2	100.06	10,000	2,500		5+
22	Jan. 12	M.	Chicago	Big 4	31	Sleeper	Cincinnati, O.	0	0	0	163	6	360.0	300	220		5-
23	Jan. 12	M.	Chicago	Big 4	43	Coach	Cincinnati, O.	2	0	0	102	9	240.05	50	10		4-1+
24	Jan. 12	M.	Chicago	Big 4	43	Sleeper	Cincinnati, O.	12	0	0	91	15	360.0	400	54		4-1+
25	Jan. 12	M.	Chicago	Soo	2	Diner	Waukesha, Wis.†							3,500	300		5-

26	Jan. 19	S.	Chicago	C. & E. I.	21	Car 492	Chicago	3	0	0	161	24	62.0.1	1,100	69	2-3+
27	Jan. 19	S.	Chicago	Santa Fe	9	Tourist	Chicago	2	0	0	456	16	278.0.2	790	40	4-1+
28	Jan. 19	S.	Chicago	Santa Fe	9	Diner	Chicago	5	0	0	95	4	36.0.0	18	3	5-
29	Jan. 19	S.	Chicago	Santa Fe	6	Smoker	Ft. Madison	5	0	0	95	4	36.0.0	6,000	46	5-
30	Jan. 19	S.	Chicago	C. & E. I.	9	Car 432	Chicago	20	5	0	125	4	56.0.2	1,000	130	2-2+
31	Jan. 19	S.	Chicago	C. & E. I.	6	Car 976	Nashville, T.	0	0	0	85	4	46.0.0	50,000	6	5-
32	Jan. 19	S.	Chicago	Erie	47	Sleeper	Salamanca, N. Y.	20	5	0	114	4	78.0.6	500	24	4-1+
33	Jan. 19	S.	Chicago	Erie	47	Car 1037	Salamanca, N. Y.	2	10	0	37	4	14.0.1	23	4	5-
34	Jan. 19	S.	Chicago	Wabash	50	Car 1052	Forest, Ill.	26	35	0	48	4	16.1.9	5,000	20	5-
35	Jan. 19	S.	Chicago	Wabash	7	Sleeper	Montreal	30	30	0	123	6	76.0.0	710	100	5-

* Collections have been made by W. W. Hanford (H), F. W. Tanner (T), F. W. Mohlman (M), and C. H. Spaulding (S).

† Denotes bottled water.

TABLE II
Analyses of water taken from railway trains

DATE OF COLLECTION	COLLECTOR	CITY	RAILROAD	TRAIN NO.	CAR	TANK FILLED AT	TURBIDITY	COLOR	ODOR	RESIDUE	CHLORINE	MAGNESIUM	ALKALINITY		SULPHATE	IRON	BACTERIAL COUNT		B. COLI GAS FORMATION 10 cc.			
													Ph.	M. O.			Gelatin	Agar	L. B.	Coat.		
1914																						
36	May 6	M.	Chicago	M. C.	7	Sleeper	Grand Rapids	10	5	0	170	5	8.6	4.0	72	112	35.0	0 0 0.0	300	200	5-	5-
37	May 6	M.	Chicago	M. C.	7	Sleeper	Detroit	8	10	0	118	7	4.8	54	48	13.6	0 2 0.1	9	10	3-2+	3-2+	
38	May 6	M.	Chicago	Big 4	31	Sleeper	Cincinnati	2	0	0	28	0	0.0	7	8	0 0	0.4 0.05	850	600	5-	5-	
39	May 6	M.	Chicago	I. C.	10	Sleeper	Memphis	5	0	0	113	4	4.8	70	72	4.9	0.0 10.5	700	1000	2-3+	5-	
40	May 6	M.	Chicago	I. C.	12	Sleeper	Sioux City, Ia.	15	5	0	298	6	18.2	188	190	34.7	0 2 0.05	500	125	4-1+	5-	
41	May 6	M.	Chicago	Big 4	3	Diner	Buffalo	10	10	0	165	4	3.5	100	88	11.9	0 15.0 0	950	35	1-4+	1-4+	
42	May 6	M.	Chicago	I. C.	30	Sleeper	St. Paul	0	0	0	31	0	0.0	5	4	0 0	0.1 0.0	10,000	1,800	5-	5-	
43	May 6	M.	Chicago	M. C.	13	Sleeper	Detroit	2	3	0	27	0	0.0	10	4	0 0	0.4 0.0	400	200	3-2+	3-2+	
44	May 6	M.	Chicago	M. C.	13	Tourist	Boston	2	0	0	20	0	0.0	5	8	0 0	0.5 0.0	30	5	5-	5-	
45	May 6	M.	Chicago	I. C.	28	Parlor car	Dubuque, Ia.	2	0	0	123	5	9.6	86	76	8.6	0.1 0.0	550	375	5-	5-	
46	May 6	T.	Champaign	I. C.	1	Car 3131	Chicago	5	0	0	44	1	1.9	20	12	0 0	0.05 0.0	850	320	5+	2-3+	
47	May 13	T.	Champaign	I. C.	24	Car 3195	Centralia	2	0	0	31	0	1.0	8	4	0 0	0.0 0.0	20	14	5-	5-	
48	May 13	T.	Champaign	I. C.	24	Car 3777	Centralia	2	0	0	48	1	2.9	20	12	3.7	0 0 0.0	35	20	5-	5-	
49	May 13	T.	Champaign	I. C.	1	Car 2514	Chicago	3	0	0	32	0	4.8	14	8	0 0	0.05 0.1	1,350	900	1-4+	1-4+	
50	May 13	T.	Champaign	I. C.	1	Car 3182	Chicago	3	0	0	130	1	5.8	34	32	43.6	0 0 0.0	10	4	3-2+	3-2+	
51	May 13	T.	Champaign	I. C.	24	Car 2504	Centralia	2	0	0	38	0	1.0	14	12	3.3	0 0 0.0	80	10	5-	5-	
52	May 18	T.	Champaign	Big 4	16	Car 655		2	0	0	85	1	0.0	50	32	0 0	0.2 0.0	10,000	3,000	3-2+	3-2+	
53	May 18	T.	Champaign	Big 4	16	Coach 729		3	0	0	55	3	8.8	16	24	trace	0 0 0.1	27,000	3,000	5-	5-	
54	May 18	T.	Champaign	Big 4	16	Smoker 657	Peoria	10	0	0	330	30	21.6	170	244	55.1	0 15.0 2	500	800	5+	5+	
55	May 18	T.	Champaign	Big 4	16	Coach 717	Peoria	10	0	0	200	20	15.4	136	176	45.3	0 15.0 0	1,200	500	5+	1-4+	
56	May 24	T.	Champaign	I. C.	1	Car 3131	Chicago	2	0	0	60	2	9.7	38	28	trace	0 0 0.0	860	500	5-	5-	
57	May 24	T.	Champaign	I. C.	23	Car 3102	Chicago	1	0	0	48	2	2.9	20	16	trace	0 0 0.0	90	25	5-	5-	
58	May 24	T.	Champaign	I. C.	1	Car 2801	Chicago	1	0	0	118	2	7.7	62	28	21.2	0 0 0.0	850	400	5-	5-	
59	May 24	T.	Champaign	I. C.	23	Car 3162	Chicago	2	0	0	110	12	6.7	36	48	79.4	0 0 0.0	1,200	350	5-	5-	
60	May 28	T.	Champaign	I. C.	1	Coach	Chicago	2	0	0	34	3	2.9	14	12	28.0	0 0 0.0	30	3	5-	5-	
61	May 28	T.	Champaign	I. C.	23	Smoker	Chicago	2	0	0	570	42	22.1	139	260	256.0	0.1 0.1	4,000	130	4-1+	4-1+	
62	May 28	T.	Champaign	I. C.	1	Coach	Chicago	2	0	0	163	5	15.4	103	140	40.0	0 15.0 0	20,000	210	4-1+	4-1+	
63	May 28	T.	Champaign	I. C.	23	Coach	Chicago	2	0	0	502	24	28.8	280	420	130.0	0.5 0.3	600	350	4-1+	4-1+	
64	June 1	T.	Champaign	Big 4	9	Coach 684	Indianapolis, Ind.	20	5	0	253	14	15.4	143	224	58.7	0 25.0 0	6,000	1,800	5-	5-	
65	June 1	T.	Champaign	Big 4	9	Coach 655	Peoria	2	0	0	467	25	25.9	263	424	123.8	0.4 0.1	180	90	1-4+	1-4+	
66	June 1	T.	Champaign	Big 4	9	Coach 944	Indianapolis, Ind.	2	0	0	202	23	15.4	95	128	40.3	0.2 0.0	160	20	5-	5-	
67	June 1	T.	Champaign	Big 4	16	Coach 687	Peoria	2	0	0	202	23	15.4									

1914	T.	Champaign	Big 4	10	Coach 855	Peoria	0	0	260	38	11	5	130	120	42.8	0.0	0.0	12,000	8,000	5+
69	June 10	Champaign	Big 4	9	Coach 944	Indianapolis, Ind.	0	20	0	441	21	4	248	220	88.4	0.8	0.0	20,000	11,000	5+
70	June 10	Champaign	Big 4	16	Coach 697	Peoria	0	0	0	219	11	3	112	104	48.1	0.1	0.0	25,000	15,000	4-1+
71	June 10	Champaign	Big 4	9	Coach 743	Indianapolis, Ind.	0	5	0	369	20	17	234	200	76.5	0.1	0.0	30,000	10,000	5+
72	June 11	Champaign	I. C.	922	Coach 1579	Havanna, Ill.	0	3	0	25	3	5	10	44	6.2	1.4	0.0	160	40	5-
73	June 11	Champaign	I. C.	1	Coach 2507	Chicago	0	0	0	173	3	2	93	44	13.6	0.1	0.0	1,350	800	1-4+
74	June 11	Champaign	I. C.	1	Coach 2514	Chicago	0	0	0	127	2	2	94	36	8.2	0.0	0.0	1,800	1,000	5+
75	June 19	B.*	C. B. & Q.	2	Coach	Lincoln, Ill.	2	0	0	293	15	11	162	112	57.2	0.4	0.0	7,000	2,250	3-2+
76	June 19	B.	C. B. & Q.	58	Sleeper	Minneapolis, Minn.	2	0	0	146	3	6	45	36	30.9	0.6	0.0	30	3,600	5-
77	June 19	B.	Penn.	15	Coach	Ft. Wayne, Ind.	0	0	0	162	16	2	26	56	65.0	0.6	0.0	15	1,350	5+
78	June 19	B.	C. & A.	10	Smoker	Kansas City, Mo.	30	15	3m	268	12	4	88	104	83.9	0.0	0.0	80,000	30,000	5+
79	June 19	B.	C. M. & St. P.	2	Coach	Mason City, Ia.	0	0	0	170	17	10	60	92	40.3	0.0	0.0	5,500	1,600	3-2+
80	June 19	B.†	C. & A.	8	Coach	St. Louis	0	0	0	169	2	12	116	116	none	0.0	0.0	10,000	180	6+
81	June 19	B.	Penn.	25	Sleeper	Pittsburgh	0	0	0	145	4	12	116	90	none	0.0	0.0	220	35	3-2+
82	June 19	B.	C. B. & Q.	56	Sleeper	Kansas City, Mo.	0	0	0	185	7	12	64	76	60.1	0.0	0.0	340	450	3-2+
83	June 19	B.	C. M. & St. P.	12	Sleeper	Kansas City, Mo.	5	0	0	142	6	5	50	48	42.8	0.0	0.0	900	2,250	3-2+
84	June 19	B.	Penn.	17	Parlor car	Chicago	10	0	0	158	5	9	114	76	20.6	0.0	0.0	10,000	6,400	3-2+
85	June 23	C.*	M. C.	17	Sleeper	Detroit	2	0	0	128	4	10	64	48	trace	0.0	0.0	1,350	230	5-
86	June 25	C.	M. C.	17	Sleeper	Detroit	2	0	0	23	10	6	18	8	trace	0.0	0.0	2,900	1,260	5-
87	June 25	C.	M. C.	17	Parlor car	Detroit	2	0	0	58	3	10	36	32	trace	0.0	0.0	5,000	510	3-2+
88	June 25	C.	M. C.	13	Coach	Detroit	2	0	0	166	25	18	96	48	trace	0.0	0.0	9,000	520	5-
89	June 25	C.	M. C.	13	Sleeper	New York	2	0	0	48	3	5	22	8	trace	0.0	0.0	1,560	640	3-2+
90	June 25	C.	M. C.	13	Sleeper	New York	3	20	0	120	5	15	58	72	trace	0.0	0.0	220	91	3-2+
91	June 25	C.	I. C.	24	Parlor car	Mattoon	5	15	0	302	12	33	252	144	trace	trace	0.0	8,100	6,000	4-1+
92	June 25	C.	I. C.	24	Coach	Mattoon	1	0	0	44	2	8	16	4	trace	0.0	0.0	260	183	5-
93	Dec. 30	H.*	I. C.	23	Smoker	Chicago	2	3	0	24	6	4	21	15	0.0	0.1	0.0	10,000	17	5-
94	Dec. 30	H.	I. C.	24	Coach 2166	Centralia	2	0	0	124	5	12	95	76	0.0	0.1	0.0	25	2	5-
95	Dec. 30	T.*	I. C.	1	Coach 3107	Centralia	2	0	0	426	35	19	124	192	16.7	0.2	0.0	13	33	5-
96	Dec. 30	H.*	I. C.	24	Coach 2127	Centralia	2	2	0	28	6	0	21	0	0.0	0.3	0.0	14	4	5-
97	Dec. 30	T.*	I. C.	1	Coach 2507	Chicago	0	0	0	81	8	6	35	32	trace	0.5	0.0	3,000	120	4-1+
98	Dec. 30	T.	I. C.	1	Coach 2515	Chicago	0	2	0	132	16	10	42	54	4.8	0.1	0.0	1,200	14	5-
99	Dec. 30	H.*	I. C.	1	Diner	Hammond, La.	0	2	0	179	7	21	109	un-	0.0	0.3	0.0	250	110	5+
													det.							
100	Dec. 31	T.*	I. C.	1	Coach 2117	Chicago	3	0	0	60	5	4	32	un-	0.0	0.0	0.0	5	6	5-
101	Dec. 31	H.*	I. C.	1	Parlor car	Chicago	25	0	0	175	6	6	114	80	0.0	1.6	0.0	1	10	5-
102	June 25	C.*	I. C.	23	Coach	Chicago	1	0	0	27	3	0	0	0	trace	0.0	0.0	580	200	4-1+

* Collections were made by F. W. Mohlman (M), F. W. Tanner (T), A. N. Bennett (B), H. P. Corson (C), W. W. Hanford (H).

† Denotes bottled water.

determination using 100 cc. of distilled water. The number of cubic centimeters of $\frac{N}{10}$ acid used for the distilled water less the number of cubic centimeters $\frac{N}{10}$ acid used for the sample times 40 equals the number of parts per million of hardness as CaCO_3 . When the alkalinity exceeds the hardness, carbonates or bicarbonates of sodium or potassium are indicated.

Iron. Standard Methods, page 45.

Lead and copper. Use 100 cc. of water, add 2 grams pure crystals of ammonium chloride, 2 cc. acetic acid and 2 to 3 drops of 10 per cent sodium sulphide (Na_2S) solution. Compare immediately with standards containing known amounts of lead nitrate. The standards should contain 0.01, 0.02, 0.03 mg. of Pb.

Number of bacteria per cubic centimeter. The total number of bacteria developing on gelatin incubated 48 hours at 20°C . Standard Methods, 1905, page 82. Total number of bacteria developing on standard agar plates incubated for 24 hours at 37°C . See *Public Health Reports*, November 6, 1914, page 2960.

B. coli. See *Public Health Reports*, November 6, 1914, page 2960.

Ninety-nine samples were examined for turbidity. Of these 70 showed a turbidity less than 5 parts per million; 82 less than 10; 89 less than 15; and only 10 showed 15 or more. A turbidity below 10 would not make the water appear unattractive and it would seem not unreasonable to require a standard of 10 or less.

Ninety-nine samples were examined for color. Seventy-nine of the samples had a color less than 5 parts per million; 88 less than 10; 93 less than 20; and only 6 had 20 or more. A color requirement of 20 or less should be easy to meet and it would not be impossible to meet a requirement of 10 or less.

Ninety-nine samples were examined for residue. Of these 28 had a residue less than 50 parts per million; 36 less than 100; 75 less than 200; 84 less than 300; 90 less than 400; 95 less than 500; and only 4 above 500. The very low residues are undoubtedly due to the presence of melted ice in the coolers. The few samples containing more than 500 parts per million would indicate that a standard of 500 or less could easily be made.

Chlorine was determined in 99 samples. Of these 46 had less than 5 parts per million; 66 had less than 10; 75 had less than 15; 82 had less than 20; 90 had less than 25, and only 9 more than 25 parts per million. It should not be difficult to obtain a water containing less than 15 parts of chlorine per million and it should certainly be easy to obtain water containing less than 25 parts per

million. In special cases where it is not possible to obtain waters with low mineral content, exceptions to the rule may be made. The same may be true also of residue, magnesium sulphates, alkalinity and hardness.

Sixty-six were examined for magnesium. Of these 39 contained less than 10 parts per million; 51 less than 15; 60 less than 20, and only 6 more than 20 parts per million. In the large majority of cases, therefore, it should be easy to obtain waters containing less than 20 parts per million of magnesium. If the magnesium were all present as sulphate, 20 parts of magnesium would be equal to 100 parts of magnesium sulphate.

The alkalinity using phenolphthalein and methyl orange as indicators was determined in 99 samples. In only one case was a water found which was alkaline to phenolphthalein. A requirement that the alkalinity to phenolphthalein shall not be greater than one-half the alkalinity to methyl orange would be easy to fulfill and would guard against the use of water over-treated with lime. Forty-three samples contained less than 50 parts of alkalinity to methyl orange, 71 less than 100, 89 less than 200. Only 10 had an alkalinity of over 200, and only one of more than 300. A standard of 300 or less would be very easy to maintain and a standard of 200 or less would not be impossible.

The total hardness was determined on 64 samples. Of these 34 had a total hardness of less than 50; 45 less than 100; 57 less than 200. Only 7 had a hardness of more than 200 and but 2 a hardness of more than 300. A limit of 300 would be very easy to maintain and it should not be difficult to obtain waters containing less than 200.

Sixty-six waters were examined for sulphates. Thirty-six waters contained less than 10 parts per million of SO_4 ; 42 less than 25; 54 less than 50; 63 less than 100, and only 3 more than 100. It should be apparently very easy to furnish waters having less than 100 parts per million of sulphates.

Ninety-nine samples were examined for iron. Eighty-six of these contained less than 0.5 parts per million of Fe; 94 less than 1.0; and only 5 had more than two parts per million. A standard of less than one part per million would be very easy to maintain and it would not be unreasonable to ask for less than 0.5 parts.

Sixty-six samples were examined for lead and copper. Fifty-six of these showed no trace of either metal; 7 contained 0.1 part per million; 2 contained 0.2, and 1 contained 0.3. It would not seem difficult to maintain a standard of less than 0.3 part per million.

One hundred samples were plated on gelatin and the number of colonies counted at the end of 48 hours. Of these, 29 samples had less than 99; 16 samples from 100 to 499; 16 from 500 to 999; 9 from 1000 to 1999; 9 from 2000 to 9999; and 21 more than 10,000.

One hundred and two samples were plated on agar and incubated at 37.5°C. for 24 hours. Forty samples showed less than 50 bacteria per cubic centimeter; 7 from 50 to 99; 8 from 100 to 199; 14 from 200 to 499; 8 from 500 to 999; 10 from 1000 to 1999; 10 from 2000 to 9999; and 5 had more than 10,000.

While the large number of bacteria may consist for the most part of harmless forms, the results would indicate unsatisfactory conditions, either in the original water taken or in the conditions of storage and delivery.

The Commission on Standards have made no recommendation concerning the use of gelatin but their standard of less than 100 growing on agar would mean that 53 per cent of the waters examined were unsatisfactory.

One hundred and nine positive tests for gas formation were obtained in 67 samples examined after May 1. Ninety-one, or 83 per cent, of these were shown by the confirmatory tests to contain *B. coli*.

Twenty of the 67 waters were shown to be unsatisfactory by both the standard for *B. coli* and agar count of the Commission on Standards of Purity for Common Carriers. Four more did not conform to the *B. coli* standard alone and 24 more did not conform to the agar count standard, making a total of 49 of 67 samples or 73 per cent which did not conform to the standards set by the Commission.

While our methods differ from Creel (*Hygienic Laboratory Bulletin* 100, 43-57) the results judged by the *B. coli* standard are similar, showing that a better water is found on sleeping cars and parlor cars and the poorer water is found on coaches and smoking cars.

Mr. W. W. Hanford of the Illinois State Water Survey is making a study of the character of the water supplied to railway trains from points in Illinois. As time permits we expect to make more analyses of samples of water taken from trains. An improvement is to be expected as the railway officials are endeavoring to improve conditions as rapidly as possible.

Credit must be given to the members of the laboratory staff of the Illinois State Water Survey for the work which is described in this article.

WATER SUPPLY TREATMENT AT COUNCIL GROVE, KANSAS

BY LOUIS L. TRIBUS

Among the first essentials in the practical training of engineers is to learn not to despise the day of small things, and to watch and note every strange phenomenon that catches the eye or ear. Countless small scale experiments in the laboratory have resulted in great accomplishments; small models usually exhibit in action the principles that govern full sized productions. More thought and skill are often required to secure efficiency and economy in the design and construction of the small public utility plant than for the much larger ones. Unnecessary first cost and a small annual waste in the one may be a much more serious burden than would be much greater freedom of original expenditure and a larger percentage of annual waste in the other. The writer therefore has no apology to make in presenting for record, and perchance for bringing out some helpful discussion, the following notes about a small water works plant at Council Grove, Kansas.

The real westerner is so accustomed to seeing big mountains, big plains and big rivers, that he naturally uses the big titles even though the object may be really small of its class. Council Grove therefore is a "city," though possessing less than 3000 inhabitants, but it has all the characteristics and aspirations of much larger confrères (Fig. 1). The Neosho River, which bisects it, has but 241 square miles of tributary watershed above Council Grove, yet exhibits many of the unfortunate water supply qualities of its friends and neighbors, the Missouri and Arkansas, which latter ultimately engulfs it, with some additional uncomfortable qualities thrown in.

The vicinity of Council Grove is typical "plains" region; rolling land with about 100 feet differences in elevation; some sharp ridges and many abrupt gulches; white limestone the abundant underlying and outcropping rock. The rock strata are not largely water bearing; gravel and sand deposits are scanty and so permeated with clay as to be of but small service for water storage. Such water as finds its way into the rock seams gradually works out into

of law and engineering, and the writer's firm was authorized to design and carry out the necessary changes, which have been recently completed.

What time may demonstrate as continuing success under all conditions is unknown, but in the few months of operation, dealing some of the time with liquid mud, an effluent of zero turbidity has been delivered, while also meeting continuously the following test conditions.

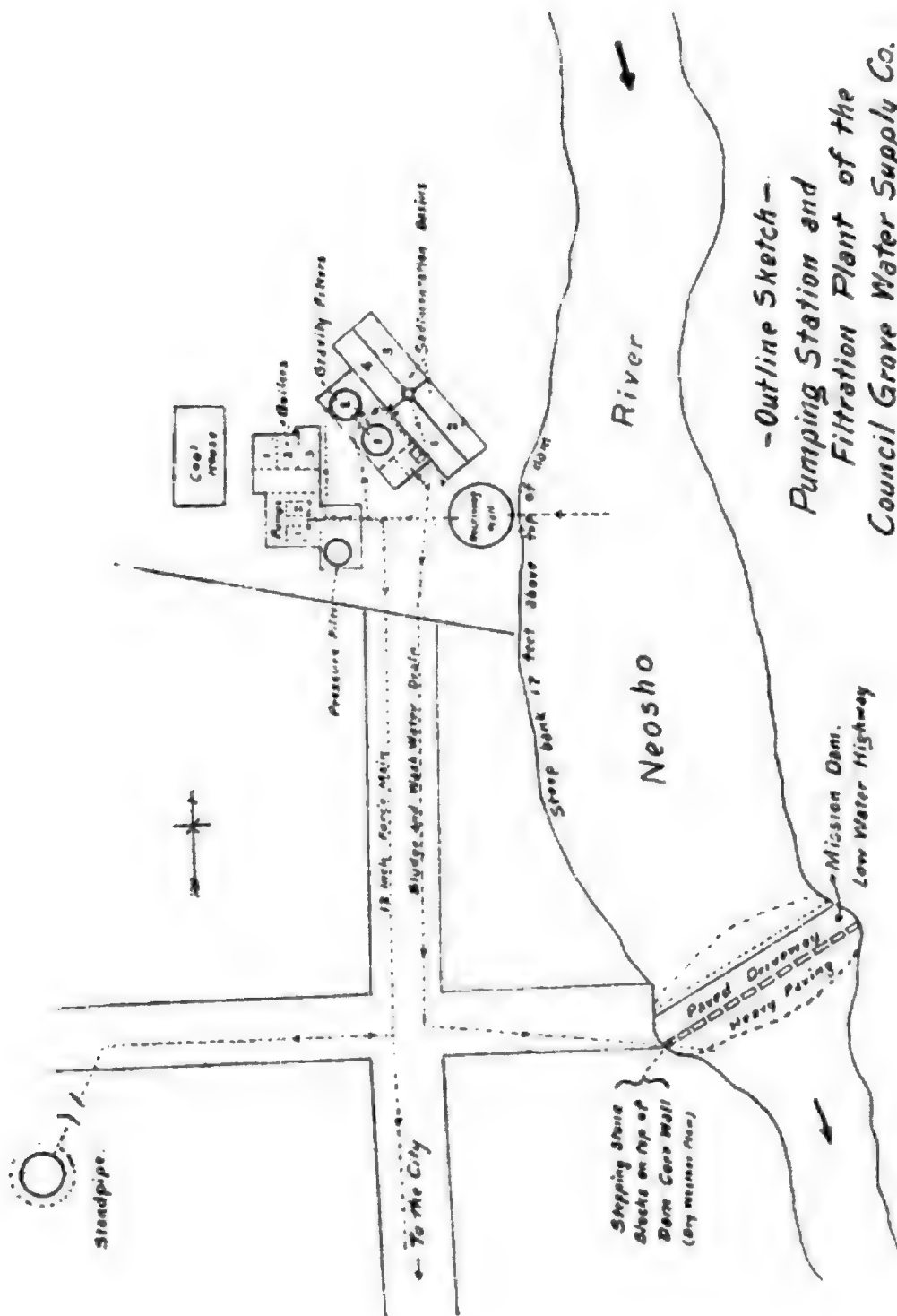
The test required for the filtered water shall be a reduction of bacterial content of at least 98 per cent from the content in the raw water, except that when the total number of bacteria is less than 3500 per cubic centimeter in the raw water, the filtrate must not contain in excess of 75 per cubic centimeter.

The filtrate also must be without color, odor or turbidity, or free or decomposed alum, or aluminum hydrate.

During the past twenty-five or so years, the problems of water treatment have received great attention; those of Europe and the eastern United States have yielded under different methods and care practically perfect results as to potability and softness, but the western colloidal waters are still continuously under experiment with only partial success.

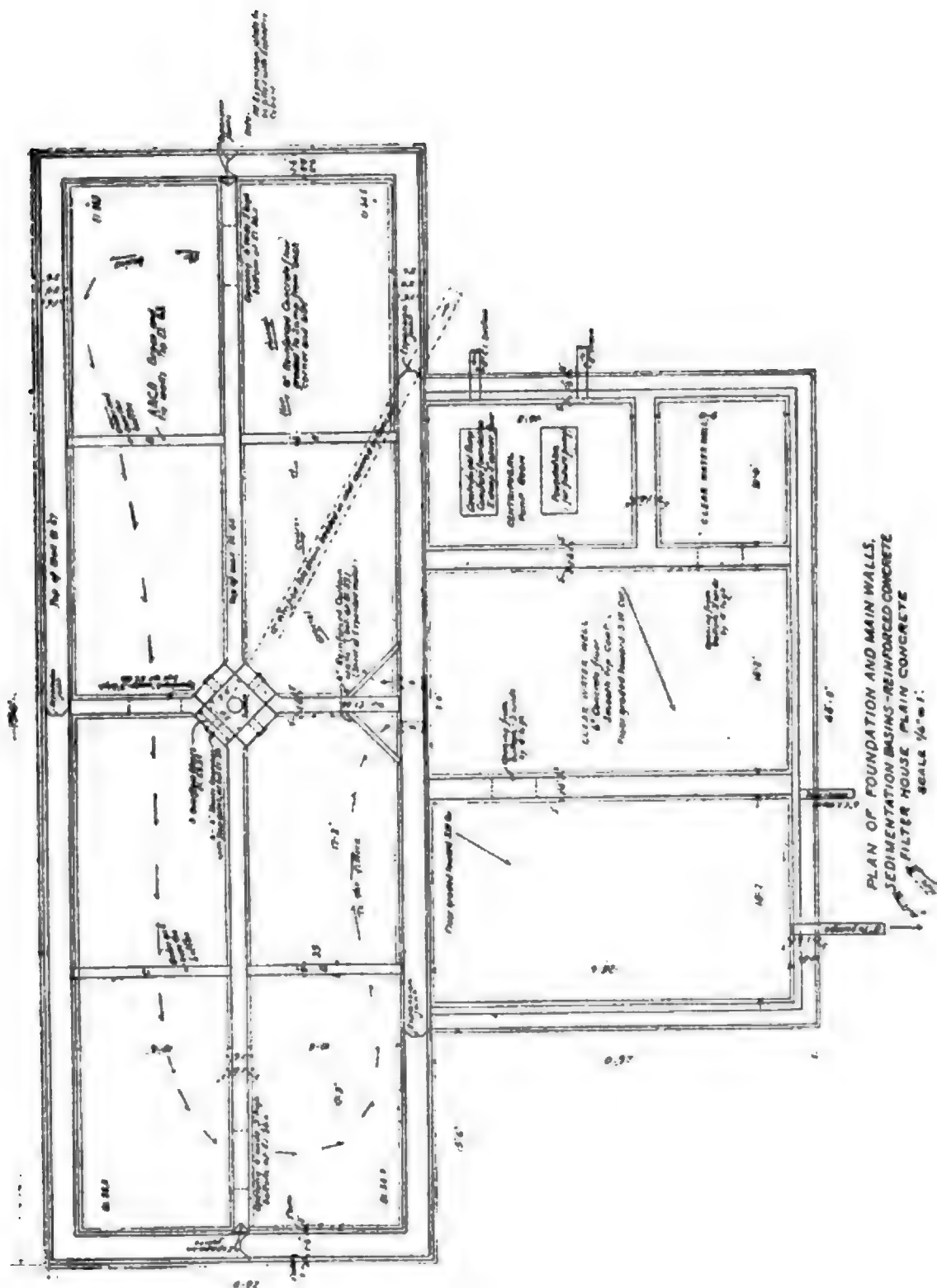
The writer does not consider the Council Grove plant ideal in design, for it had to be built to supplement existing works, but it makes possible the handling of the peculiar type of water available, with some degree of scientific care and with practical success.

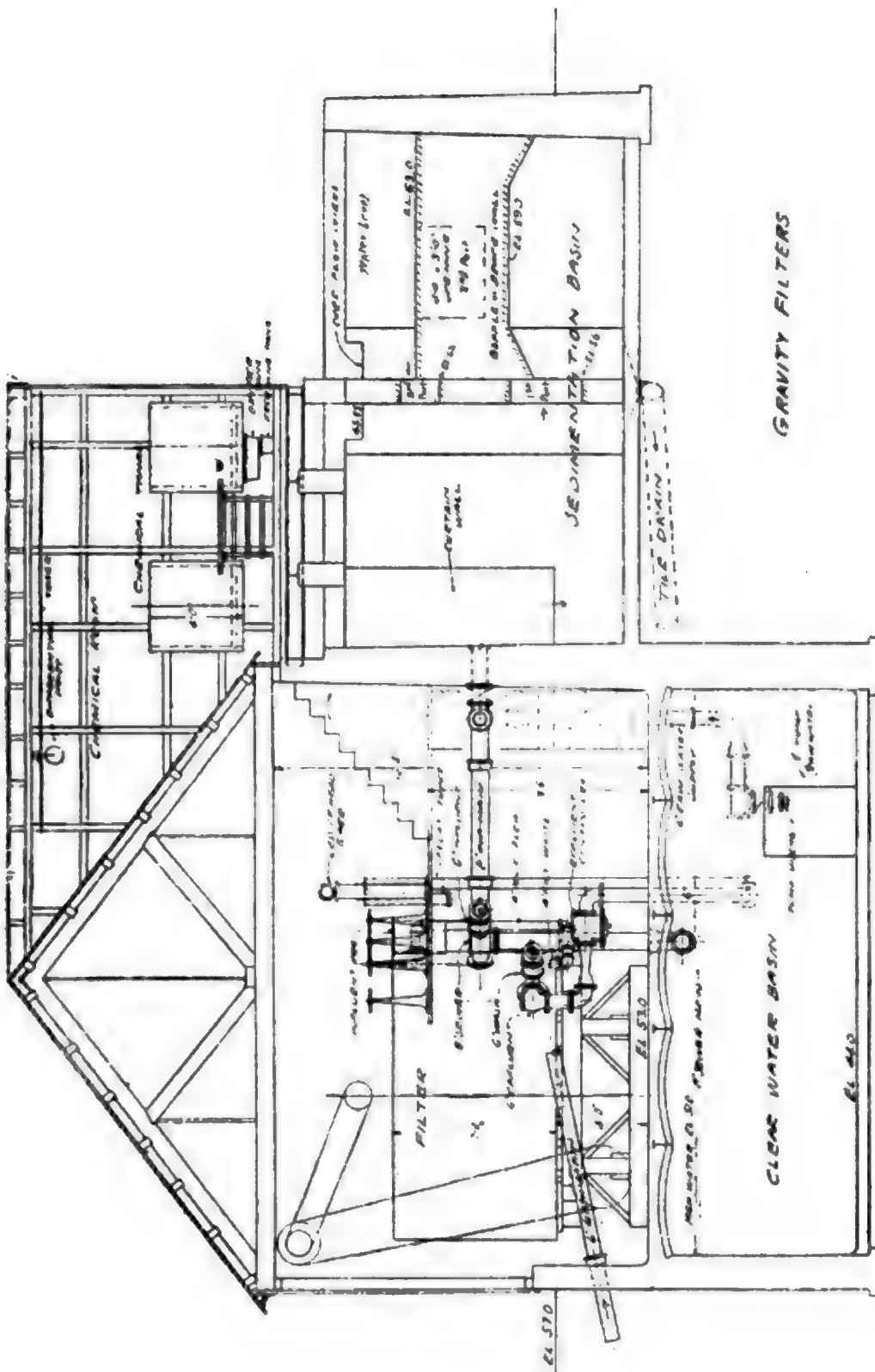
Briefly described, the water flows through a pipe inlet into a deep 30-foot diameter river-side stone well, from which a 600,000-gallons per 24 hours centrifugal pump lifts it, a combined suction and discharge of 28 feet at low water, to sedimentation basin No. 1, or by cutout to the gravity filters direct. The overflow level of the basins is 3 feet above the sand in the filters. From basin No. 1, which it enters at one end near the bottom, the water flows nearly to the farther end through a low level submerged port connecting with basin No. 2, similarly flowing into No. 3 through a higher level port, and into No. 4 through an opening 18 inches below the upper surface of the water. From No. 4, at similar high level, though still submerged, the water passes to the two 250,000 gallons gravity, rake-agitated and clean-water-back-washed Jewell filters. In each basin, flow is also somewhat checked by cross baffles (Plates I, II III).



-Outline Sketch-
Pumping Station and
Filtration Plant of the
Council Grove Water Supply Co.
Council Grove, Kan.

PLATE I





ELEVATION
SCALE 1/8" = 1'
PLATE III

The coagulant is mixed in carefully proportioned quantities and fed through automatic orifice boxes and sight feeds, as experiments show to be best under the differing conditions, at either all possible points, or in any combination or singly (Fig. 3).

1st. At the pump suction; 2d. Inlet to basin No. 1; 3d. At port between basins 2 and 3; 4th. In influent pipe to filters.

From the gravity filters the water passes down to a clear water well in the basement which stores about 40,000 gallons; from this the main water works pumps draw it without lift, delivering into the city system; excess over demand being stored in the stand-pipe for night use. At the suction inlet there can be given a regulated dose of hypochlorite, if the bacterial condition should seem to require (Fig. 4).

If the new plant should be overburdened at any time and fail to give perfect water, the pumps can drive it in final treatment through the old pressure filter. Tried out as a test this worked effectively. The sedimentation basins (Fig. 5) hold about 125,000 gallons in their 11 feet of depth and can be cleaned out into a sewer which opens from a central overflow and drainage sump, through shear valves, operated from the top of the sump. If all the coagulant was added at one point, either at the inlet, or outlet from the basins, the settled mud in them would be some criterion of action, but as a different condition usually prevails, the regularity of deposit and turbidity is interfered with.

Following the first month of operation, a heavy silt period, the basins were cleaned showing average depths of mud as follows: No. 1, 29 inches; No. 2, 24 inches; No. 3, 16 inches; No. 4, 13½ inches; and frequent washings of the filters were necessary, say four or five times per day. The next month, with better water conditions, indicated mud depths as follows: No. 1, 12 inches; No. 2, 6 inches; No. 3, 5 inches; No. 4, 5½ inches; and much less frequent filter washings, say twice a day, while in January, turbidity was almost nil and filter washings sufficed at twice a week.

During the test days in October, 1914, samples of water were taken at various depths and locations, thoroughly crosssectioning the basins, and turbidity readings were compared, indicating the effect of coagulation and subsidence. Even though the water had very slow movement the effect was shown quite handsomely; the minimum turbidity appearing to be between 2 and 4 feet below the surface (Plate IV). At time of these tests, however, the port

The Kansas laws give a very large measure of authority over water works and sewerage systems and the state Board of Health is very efficient in living up to its duties. After conference, that board accepted the responsibility through its division of water, of conducting the acceptance test of the improved plant, so such acceptance was made a condition in the company's contracts for construction. Mr. C. A. Haskins, engineer of the division of water, and the writer conferred as to many of the matters at interest, and Mr. F. R. Hesser, assistant engineer, was finally assigned to conduct the agreed upon tests.

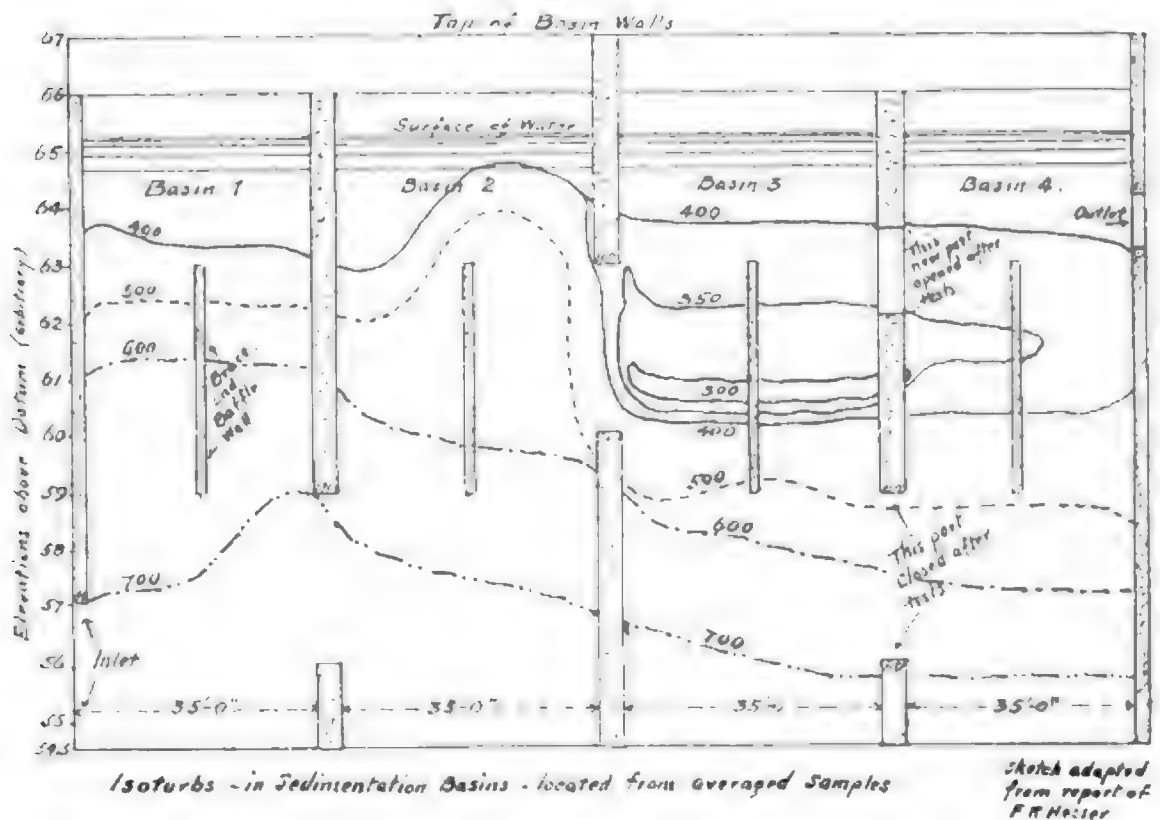


PLATE IV

From Mr. Hesser's report December, 1914, the following extracts will be of interest; summing up, as they do very nicely, the mechanical, chemical and bacteriological action of the plant.

On the night of October 9, a very heavy rain fell in the Neosho Valley above Council Grove and about three feet of water was running over the dam on October 10. The turbidity of the raw water was raised to 1500-1800 parts per million. A portion of this turbidity was so finely divided that a third passage through filter paper failed to remove it. The alkalinity of the raw water was reduced to 50 p.p.m., but the effect of the high turbidity upon the

pin floc appeared on the filters and this rapidly increased to heavy flakes, which settled rapidly. The filter effluent at once became clearer until at 5 p.m. the turbidity of filtered water was approximately 10 p.p.m. This production of floc was accompanied by a rapid reduction of alkalinity, the filter effluent at 5 p.m. having 8.5 p.p.m. of alkalinity.

The total alum dose was now reduced to 14 grains per gallon and filtration proceeded satisfactorily until the day's run was closed at 6.30 p.m.

Tables I and II show the results of determinations made during the day, with the exception of special determinations shown by tables entitled, "Turbidity Readings."

TABLE I

		ALKALINITY	TURBIDITY
Raw water at 10.30 a.m.....	Oct. 10, 1914	50	1500
Settled water, basin 4.....	10 30 a.m.	63	—
Settled water, basin 4.....	11.15 a.m.	44	750
Filtered water.....	11.15 a.m.	46	600
Settled water, basin 4.....	12.30 p.m.	35	950
Filtered water.....	12.30 p.m.	20	500
Filtered water.....	3.30 p.m.	18	50
Filtered water.....	3.45 p.m.	14	50
Filtered water.....	5.00 p.m.	8.5	10

TABLE II

(Extracts from Table I)

Date: Oct. 10, 1914.

Time: See Table.

Alum dose: About 8 grains at inlet; 8 grains between basins 2 and 3; 4 grains on filters.

SAMPLE	TIME	TURBIDITY
Raw water.....	10 30 a.m.	1500
Basin No. 4.....	11.15 a.m.	750
Filtered water.....	11.15 a.m.	600
Basin No. 4.....	12.30 a.m.	950
Filtered.....	12.30 a.m.	500

Tables III and IV show the results of some special determinations made at this time. Samples taken from the river and from the outlet ends of the four compartments, with the results, are shown in Table III. It is evident that the heavier suspended matter has remained near the bottom of compartment 1, but is gradually brought nearer the surface as the water flowed through the basins.

In order to learn, if possible, the path of maximum turbidity through the basin and the effect of the tie walls and ports upon the path, I decided to take

samples at various depths in several planes across each compartment, determine the turbidity of each and thus be enabled to plot the lines of equal turbidity both in plan and elevation, from inlet to outlet. Samples were to be taken at depths of 1 foot, 5 feet and 10 feet or at intermediate points where sharp differences in turbidity were noted. To collect the samples, an 8 ounce drug bottle was securely fastened to the end of a 12-foot pole and a cork was attached to a string, by which it could be removed from the bottle when the bottle had been submerged to the proper depth. A Jackson Turbidimeter tube was used with an electric battery and 1 candle power bulb, in place of the standard candle. Before determining the turbidity of individual samples, an average sample was taken from each compartment as follows: An 8-ounce sample was taken at each sampling point at depths of 1 foot, $4\frac{1}{2}$ feet and $8\frac{1}{2}$ feet. Equal volumes of each of the 27 samples thus taken in each compartment were combined to form an average sample of that compartment.

Table IV shows the results obtained. It will be noted that the average turbidity in basin 2 is higher than in 1; that basin 3 shows a reduction of 45 per cent from No. 2 and 35 per cent from No. 1; while No. 4 has an average turbidity higher than that of the first compartment.

The examination of individual samples was taken up about 3 p.m. October 10, but had to be discontinued before the first compartment was completed, because of the burning out of the bulbs used in the flash light. A candle turbidimeter was not at hand and the work could not be completed. On October 12, however, Mr. Tribus took samples at the previously described points from depths of 2 feet, 4 feet, 6 feet and 8 feet. The three samples for each depth on each horizontal line across the compartment were mixed and the resultant turbidity determined approximately by comparison with that of bottled samples previously examined with the turbidimeter. These results are shown in Table V.

Plate IV is a group of curves showing the variation in turbidity along each level, in a diagram of the basins developed along the line of flow, and the probable lines of equal turbidity as determined by the limited data of Table V. This merely illustrates the possibilities of this method of studying basins where sufficient data are obtained.

It was obvious that the basin as arranged was not efficient. The mud evidently settled to the floor, but the depth of the ports between compartments 1 and 2 and 3 made it possible for the most turbid water to be carried through the ports, impinge on the opposite wall and rise in a boil near the center of the basin. These boils were, in fact, visible in basins 2 and 4. It was, therefore, thought best to close the port between No. 3 and No. 4 and cut a new one 4 feet wide by 1.5 feet high, with its bottom 8.5 feet above the basin floor. This change had been made at the time of the last visit but the low turbidity of the raw water made it impossible to determine what its effect may be.

The basins are designed to give a 6-hour retention period on the basis of 500,000 gallons filtered per 24 hours. The actual period is probably approximately 4.5 to 5 hours.

TURBIDITY READINGS

TABLE III

Date: Oct. 10, 1914.

Time: 12.30 p.m.

Raw water: Turbidity 1500.

Alum dose: 8 grains at inlet, 8 grains between basins 2 and 3; 4 grains on filters.

	<i>Sample</i>	<i>Turbidity</i>
Basin No. 1.	Outlet end, 1 foot depth.....	340 p.p.m.
Basin No. 2.	Outlet end, 1 foot depth.....	675 p.p.m.
Basin No. 3.	Outlet end, 1 foot depth.....	925 p.p.m.
Basin No. 4.	Outlet end, 1 foot depth.....	1000 p.p.m.
Water on Filters.....		900 p.p.m.
Filter Effluent.....		500 p.p.m.

TABLE IV

Date: Oct. 10, 1914.

Time: 3 p.m.—4 p.m.

Raw water: Turbidity—1500.

Alum Dose: Same as above.

	<i>Sample</i>	<i>Turbidity</i>
Basin No. 1.	Average Sample.....	650 p.p.m.
Basin No. 2.	Average Sample.....	750 p.p.m.
Basin No. 3.	Average Sample.....	420 p.p.m.
Basin No. 4.	Average Sample.....	700 p.p.m.

TABLE V

Date: Oct. 12, 1914.

Results reported by Mr. Tribus.

Raw Water Turbidity:—750.

BASIN	SAMPLE	DEPTH OF SAMPLE			
		2 feet	4 feet	6 feet	8 feet
1	1 (a)	520	600	615	700
	1 (b)	410	610	615	
	1 (c)	400	600	700	
2	2 (a)	340	580	625	700
	2 (b)	510	535	615	
	2 (c)	480	550	625	
3	3 (a)	375	330	515	650
	3 (b)	375	325	500	
	3 (c)	375	325	535	
4	4 (a)	390	350	525	600
	4 (b)	390	350	525	
	4 (c)	400	400	550	

RESULTS AND RECOMMENDATIONS

CHEMICAL DOSING AND ACTION

Determinations made November 16, 17 and 18 show a practically normal alkalinity reduction per grain of alum. The dosage was as follows: During the morning of November 16, 2.6 grains of alum per gallon introduced at the inlet to basin No. 1, and 2.3 grains in the influent pipe. Not much floc on basin No. 1 but good in the following basins. Very heavy floc on the filters. At noon, the influent dose was reduced to 1.1 grains per gallon and the raw water dose applied to the pump suction instead of inlet well. A good floc soon appeared in basins, due probably to better mixing in the pump, and carried completely around them. At 10.15 a.m. the pump suction dose had been reduced to 1.6 grains per gallon and a fair floc continued to appear in basin No. 4. With the low turbidity existing at this time, clarification in the basins is not the object sought by coagulation, but the formation of a schumtzdecke on the filters.

It seems probable that by applying a dose of about 1 to 2 grains per gallon between basins 2 and 3, the influent dose might be dispensed with, except for perhaps two hours after starting a new run. At 7.30 a.m., November 18, the raw water dose of 1.6 grains was changed to the port between basins 2 and 3, and 1 grain per gallon was applied to the influent pipe for two hours and then cut out. Samples taken at 10.30 and 11.00 a.m. showed very satisfactory bacterial counts, but can hardly be taken as strictly representative samples, since only 3 hours had elapsed since making the change.

The results of alkalinity and turbidity determinations and bacterial plates made during the test run of November 16, 17 and 18 are reviewed as follows. The filters had been washed at 5.30 p.m. November 15 and allowed to stand idle over night. The sand beds were agitated slightly by the rakes the following morning and the run started at 7.30 a.m.

The first samples were taken from the controller petcocks at 9.15 a.m. and at frequent intervals thereafter. Filter No. 1 was washed thoroughly at 9.25 a.m. and was then operated continuously, except for washing periods until 11.15 a.m. November 17, and the bacterial counts in samples taken from No. 1 during its run are very satisfactory, the maximum being 75 per cc. and the minimum 12 per cc. The samples taken from the power house tap and from No. 2 are not so good, but it must be remembered that No. 2 filter was being subjected to drop tests during the time and the consequent rough treatment doubtless increased the bacterial count in its effluent, as well as in the combined effluent of Nos. 1 and 2. After 11.15 a.m., November 17, filter No. 1, was also being subjected to drop tests. Filter No. 2 was washed at 10.15 a.m. November 18 and both filters operated uniformly until 11.00 a.m. The sample then taken from the power house tap, and that from the Controller No. 1 show satisfactory counts. Samples of raw, coagulated and filtered water from the power house tap were collected at noon, November 18, and shipped to the laboratory where they were plated and fermentation tubes inoculated. The results indicate a satisfactory effluent.

The results indicate that a 5-minute period of filtering to waste after washing will give a satisfactory effluent during periods of low turbidity. The alum

COUNCIL GROVE WATER SUPPLY CO.														
Filter Plant Daily Record for Week beginning Sunday....., 19..														
Day	Temperature			Alkalinity		Turbidity		Clear water		Washing (totals)				
	Air	Water	Bar	raw	filtrate	raw	filtrate	gals.	ft.	#1	#2	Pressure		
	high	low	in ft.							gals.	Minutes	Minutes	Minutes	Minutes
Sun.														
Mon.														
Tues.														
Wed.														
Thurs.														
Fri.														
Sat.														
Sun.														
Time of operating filters														
Day	#1 (gravity)		#2 (gravity)		Pressure		Total HOURS	WATERING RATE						
	from	to	from	to	from	to		#1	#2	Pressure				
Sun.														
Mon.														
Tues.														
Wed.														
Thurs.														
Fri.														
Sat.														
Week total														
Day	lbs.	ALUM				LIME lbs.	HYPOCHLORITE lbs. per 1000 gal.	Remarks						
		Orifice settings	Orifice settings	Orifice settings	Orifice settings									
Sun.														
Mon.														
Tues.														
Wed.														
Thurs.														
Fri.														
Sat.														
Sun.														
								Supt.						

FIG. 9

dose probably may safely be reduced to 1 grain per gallon introduced between compartments 2 and 3, with a secondary dose of $\frac{1}{4}$ to 1 grain per gallon in the influent line for two hours after starting a run during such period of low turbidity. A marked decrease in the raw water temperature from that noted during the test, 6 degrees C., may necessitate the introduction of the dose at the pump suction.

During periods of high turbidity, it will be necessary for the operator to experiment with the amount and points of introduction of the alum dose, in order that a method of treatment which will effect the most economical and efficient coöperation between settling basin and filters may be obtained. Turbidity and alkalinity readings should be taken daily or oftener and the amount of doses and points of application recorded for future guidance.

Until absolute certainty in operation is attained, hypochlorite should be kept on hand and used in doses of 8 to 10 pounds per million gallons filtered, whenever there is any question as to the quality of the effluent. I believe that the filters are capable of delivering a pure and wholesome effluent with proper operation, and I recommend that they be accepted on condition that adequate effluent controllers be provided.

The engineers of the filter manufacturers, the Kansas State Board of Health and Messrs. Alvah Smith and Arthur E. Smith (the latter representing the writer's firm on the work) all took a very active and helpful interest during design, construction and testing.

As the water company may find possible, without undue expense, further testing will be carried out, while constant record will be kept of the more salient features that may prove helpful also in the treatment of other western waters.

The forms for daily records (Fig. 9) are not as complete as would be the case if a much larger plant was involved and a chemist kept employed, but the very careful superintendent (Mr. A. Moser, Jr.) has already done much experimenting, and engineers from the Kansas State Department of Health, Division of Water, will make frequent visits and make bacteriological tests from samples then taken, so that the station may quite well become of value, not alone to Council Grove, but in helping to solve some of the trying problems of water purification.

AIR BOUND FILTERS

BY JAMES M. CAIRD

There is very little literature on troubles encountered in the operation of water purification plants. The collection of air within a filter bed is a very serious matter and up to the present time the writer is not aware of any method which will successfully prevent this trouble.

The writer's idea as to the cause of air bound filters is as follows:

1st, The lower the temperature of water, the greater the volume of air it may contain.

2nd, During cold weather, water is usually saturated with air.

3rd, Water in passing through filters increases in temperature, liberating air.

4th, The voids in the gravel are greater than in the sand, therefore the air collects in the gravel.

5th, The weight of the sand in American type filters is not sufficient to hold the air in the gravel, therefore the sand beds become perforated.

6th, The weight and fineness of the sand in English type filters are such that it holds the air in the gravel, hence the filter is unable to pass water.

The action of collected air in the American type filter is entirely different from the action in English filters. In both types of filters the trouble seems to be due to the collection of air in the gravel just below the sand layer. Air bound troubles seem to be most frequent when the temperature of the unfiltered water is below 50°F.

In filters of the American type the air seems to collect below the sand until it forces its way up through the sand, perforating the bed, which of course results in imperfect filtration. In filters of the English type, the air collects in the gravel, but does not seem to be of sufficient quantity to force its way up through the bed; but it overcomes the head of water and prevents any water passing the bed.

It may be of interest to consider the air bound conditions in some places.

In the *Annual Reports of the Board of Water Commissioners*, Harrisburg, Pennsylvania, for the years 1907, 1908, 1909 mention is made of the troubles due to air collecting in the filters. The Harrisburg filters are of the American gravity type. The troubles at Harrisburg always come during the cold weather when the temperature of the water is low and the color and turbidity content of the unfiltered water are at a minimum. At such times the air collects in sufficient quantity in the gravel to force its way up through the sand, perforating the bed, and permitting undesirable water to pass. During such periods extra care is used in operating the plant and frequent inspection is made of the loss of head gauges which show when it is advisable to remove the air from the beds. When there is a loss of head of about 3.5 feet, it is advisable to put the bed out of service and apply the wash water for about two minutes, which removes the entrained air. When the air troubles exist the filters are usually given one of these short washes between the regular washes, the beds are then agitated by air. By using this method of operation it has been possible to get good filtration results.

At Bangor, Maine, where filters of the American gravity type are operating on a water which changes very slightly in composition, it is found that it is necessary to reduce the periods very materially between washings during the winter months. At Bangor, when the temperature of the unfiltered water falls to 48° F. the operator begins to reduce the periods of time between filter washings, disregarding the indicated loss of head. In winter the periods between washings are at least 50 per cent less than in summer when the temperature of the water is about 70° F. This method of operation has been very successful. These conditions are mentioned simply as illustrations and are not alone peculiar to these places.

At Wilmington, Delaware, where filters of the English type are operated at a rate of six or seven million gallons per acre per day, air has been the cause of very serious trouble. In the *Annual Reports of the Water Department*, Wilmington, Delaware, for 1911-1912, 1912-1913, 1913-1914 mention is made of the troubles caused by air bound filters. In the Wilmington case it has been necessary, at times, to "by-pass" settled water because the collected air would completely prevent filtration. If it were not for the fact, that all of the water is treated with liquid chlorine before being delivered to the consumers, the grave danger of "by-passing" would almost

amount to murder. As with the filters of the American type, the air troubles at Wilmington come when the temperature of the water is about 45° F. or below. The Wilmington filters are covered and it is found that the temperature of the water increases in passing the filter beds.

For some time past a study of the relation of the dissolved oxygen content of the unfiltered and filtered waters to the air binding of the beds has been made.

Table showing average monthly temperature, dissolved oxygen in per cent saturation before and after filtration and per cent removed, Wilmington, Del.

DATE	TEMPERATURE	PER CENT SATURATION		PER CENT REMOVED
		Before	After	
1913	<i>Degrees F.</i>			
October.....	60.5	90.79	65.43	27.9
November.....	48.5	95.06	81.54	14.3
December.....	40.2	97.76	85.94	12.1
1914				
January.....	34.6	94.18	84.07	11.3
February.....	35.6	96.97	84.29	13.1
March.....	37.8	97.39	88.30	9.4
April.....	52.6	94.19	70.09	25.6
May.....	66.0	91.49	51.75	43.5
June.....	74.6	97.08	39.03	59.8
July.....	76.2	84.70	42.70	49.6
August.....	77.2	87.20	43.80	49.8
September.....	70.0	95.20	63.20	33.7
October.....	62.7	87.80	61.10	30.8
November.....	46.4	96.80	82.90	14.4
December.....	37.6	100.00	90.90	9.1
1915				
January.....	37.4	100.00	90.80	9.2

In March and December, 1914, there were serious troubles, due to air in the beds. It is to be noted that these troubles followed a period of low temperatures of the water before filtration and that the water was about saturated with oxygen. It is also to be noted that the per cent of dissolved oxygen removed at these times is very low.

When the filters are air bound, if a bar be driven through the sand to the gravel layer, and then removed, large volumes of air will

escape. Reducing the head of water over the sand surface does not permit the air to escape.

Up to the present time the best method used to overcome this trouble is to back wash the filter bed. In doing this it is necessary to use great care so as not to displace the sand layers. This procedure of course reduces the bacterial efficiency of the filter.

PIPE DISTRIBUTION SYSTEMS¹

BY NICHOLAS S. HILL, JR.

PART I

A STUDY OF CONSIDERATIONS AFFECTING THE DESIGN OF PIPE DISTRIBUTION SYSTEMS

The occasions on which an engineer is called upon to design a distribution system "de novo" for a city of considerable size are very rare. The problem usually presented to him for solution is the design of extensions or reinforcements in an existing system with a view of improving existing pressure conditions, particularly at times of fire.

Before entering either upon the design of a new distribution system or upon the preparation of plans for the improvement of an existing one, the engineer will be called upon to consider local conditions and decide a number of preliminary questions which will affect the problem which he undertakes to solve, and hence the subsequent design.

PRELIMINARY DATA

One of the first steps preliminary to the study of a distribution system is to secure or prepare a base map of the community to be served. If possible to secure, the map should show the city and ward boundaries; present and proposed street lines, and the location of railroads and street railways. It is desirable also to obtain a contour map indicating relative elevations in the city and its environs, and the designer should have, either through the medium of a contour map or from other sources, so that the information can be added to the base map, knowledge of the elevation at street intersections. Information to be added to base maps thus secured should include the location of railroad water tanks, large industrial plants, commercial and business sections, and large fire hazards.

¹ Read and discussed at the Philadelphia convention, and now published, in revised form, for the first time. Open for discussion at the Cincinnati convention or by letter.

One base map should also be used for the purpose of showing the streets which contain improved pavements or other structures which will add to the cost of pipe laying.

In problems involving the improvement of an existing system, a map should be prepared showing the location and size of existing mains exceeding 8 inches in diameter, as well as the location of hydrants, pumping stations, filter plants, distributing reservoirs, standpipes, water tanks and towers, and the like.

Maps Nos. 1 and 2 presented herewith contain the more important data which should be made available in this form.

In addition to the data available in the form of maps, the designer should secure by local inquiry, inspection, or test, certain statistical data relating to the existing plant, including the capacity of pumping stations and equipment, filter plants, reservoirs, and critical elevations in and about the same; steam and water pressures which are and may be carried at the existing pumping stations; weight, average age, and interior condition of cast iron pipe in the existing distribution system; number of service taps and meters in use; population and water consumption statistics.

He should also have before him the results of tests made on existing hydrants, showing the pressures which obtain in various parts of the community on the date of the design, under both fire and ordinary domestic service conditions, and he should possess a general familiarity with the density and character of the dwellings in different parts of the city.

FUTURE PERIOD CONSIDERED

After having secured or prepared the necessary maps and obtained the necessary data, the engineer must consider and decide upon the future period for which the contemplated improvements are to serve without duplication or enlargement. This period will bear no relation to the useful life of cast iron pipe, which depends largely on the service for which it is used and may exceed a hundred years. It would manifestly be impossible to predict the amount or direction of a city's growth for so long a period as a hundred years with any degree of certainty. It is possible, however, to predict with sufficient accuracy, both the extent and distribution of population growth, upon which the future demand for water will in great measure depend, for a period of twenty to thirty years to come.

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The reasons for predicating estimates on results which are expected to obtain so far in the future are not that one can undertake to forecast the future with mathematical exactness even for this limited period, but rather because it is the safest and most rational way in which to make reasonable provision for future needs.

Failure to make such provision frequently results in a high capital investment in mains. It is cheaper to lay a main which is too large for present needs than to lay one which must be reinforced within a few years. To show the expense which a company or city incurs by pursuing such a policy. Table No. 1 is presented, which shows the comparative cost of different pipe sizes to give the same service.

The costs given in the table do not and, of course, can not take into consideration the damage to improved streets, and the additional cost of maintaining them, which results from continual tearing up, nor can they take into account the inconvenience, annoyance and the disturbance of traffic which results from repeated removal of the street surface. They further do not include the additional cost of repairs due to the increased main mileage which results from duplication of mains and the increased liability of having to excavate for repairs, nor any consideration of the enhanced pumping costs ensuing from greater main leakage resulting from an increase in the number of pipe joints. The table clearly shows that even where the period of usefulness of the first main laid is eighteen out of twenty-six years, the saving in favor of two mains in most cases is not sufficient to offset the other losses incurred.

POPULATION

Having determined upon the future period to be considered, the next question to arise will be the probable future population of the community to be served. All estimates of future population are based to a greater or less extent upon past growth. Proper regard must be had, however, for special conditions which have tended abnormally to accelerate or retard the rate of growth prior to the date of the design so that proper allowance may be made in the assumed or computed future rate of increase. The percentage growth in communities generally decreases as the population increases, although the total annual increase may be greater in each successive year. It is not always safe, therefore, to apply percentages based on past growth to estimates of the future growth. It has been

TABLE No. 1
Comparative cost per foot, different pipe sizes to give same service

INITIAL COST, CLASS C PIPE, @ \$21.00 PER TON IN MEDIUM DIGGING WITH LABOR @ \$1.75 PER 10 HR. DAY				RELATIVE ANNUAL COSTS PER FOOT UNDER FOLLOWING PLANS										CAPITALIZED ANNUAL COST				SAVING IN FAVOR OF PLAN 1.—THE IMMEDIATE INSTALLATION OF LARGER PIPE	
NUMBER AND SIZE OF SMALLER PIPES REQUIRED TO GIVE SAME SERVICE AS SINGLE PIPE OPPOSITE IN COL. (1)		Single pipe of diameter given in col. (1)		Single pipe of diameter given in col. (2)		Plan 1 Immediate installation of single pipe of size given in col. (1)		Plan 2 Immediate installation of single pipe of size given in col. (2) to be followed after expiration of period given in col. (5) by installation of second pipe of same size		Plan 1 (8) capitalized at 5 per cent		Plan 2 Present value of total annual cost per foot of second pipe as given in col. (1) when capitalized @ 5 per cent		Total		Amount in dollars per foot		In per cent of cost of plan 1	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14) ÷ .05 = (11) ÷ .05 reduced to present value	(15)	(16)	(17)			
inches	inches	\$	\$		\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	%			
24	2.05-18	4.61	2.87	6	23.05	1.26	24.31	14.35	0.79	15.14	4.86	3.03	2.26	5.29	0.43	8.8			
				12	23.05	1.26	24.31	14.35	0.79	15.14	4.86	3.03	1.69	4.72	-0.14	-2.9			
				18	23.05	1.26	24.31	14.35	0.79	15.14	4.86	3.03	1.26	4.29	-0.57	-11.7			
16	2.05-12	2.42	1.59	6	12.10	0.66	12.76	7.95	0.44	8.39	2.55	1.68	1.25	2.93	0.38	14.9			
				12	12.10	0.66	12.76	7.95	0.44	8.39	2.55	1.68	0.94	2.62	0.07	2.7			
				18	12.10	0.66	12.76	7.95	0.44	8.39	2.55	1.68	0.70	2.38	-0.17	-6.7			
8	2.05-6	0.96	0.69	6	4.80	0.26	5.06	3.45	0.19	3.64	1.01	0.73	0.54	1.27	0.26	25.7			
				12	4.80	0.26	5.06	3.45	0.19	3.64	1.01	0.73	0.41	1.14	0.13	12.9			
				18	4.80	0.26	5.06	3.45	0.19	3.64	1.01	0.73	0.30	1.03	0.02	2.0			

the practice in the office of the author of this paper not only to base estimates of future growth upon the past increase of population, but to check such estimates by comparing the estimated growth during, say, the next twenty years with the past growth of similarly located towns whose population twenty years ago was about equal to the present population of the town under consideration.

Several methods of estimating future growth may be used. They may be designated as follows: arithmetical progression method; comparative method; incremental increase method; geometrical progression method.

Arithmetical progression method

This method is applicable only in rare cases and almost uniformly produces estimates which are too low. The method, as its name implies, involves the assumption that the future rate of increase from year to year will be constant, and the same as has obtained in the past, or for some period which may be selected at the choice of the computer.

Comparative method

The comparative method involves the selection of cities, similarly situated, whose population, say twenty years ago, was practically the same as the present population of the town under study. The past growth of such towns is then taken fairly to represent the probable future growth of the one in question.

Incremental increase method

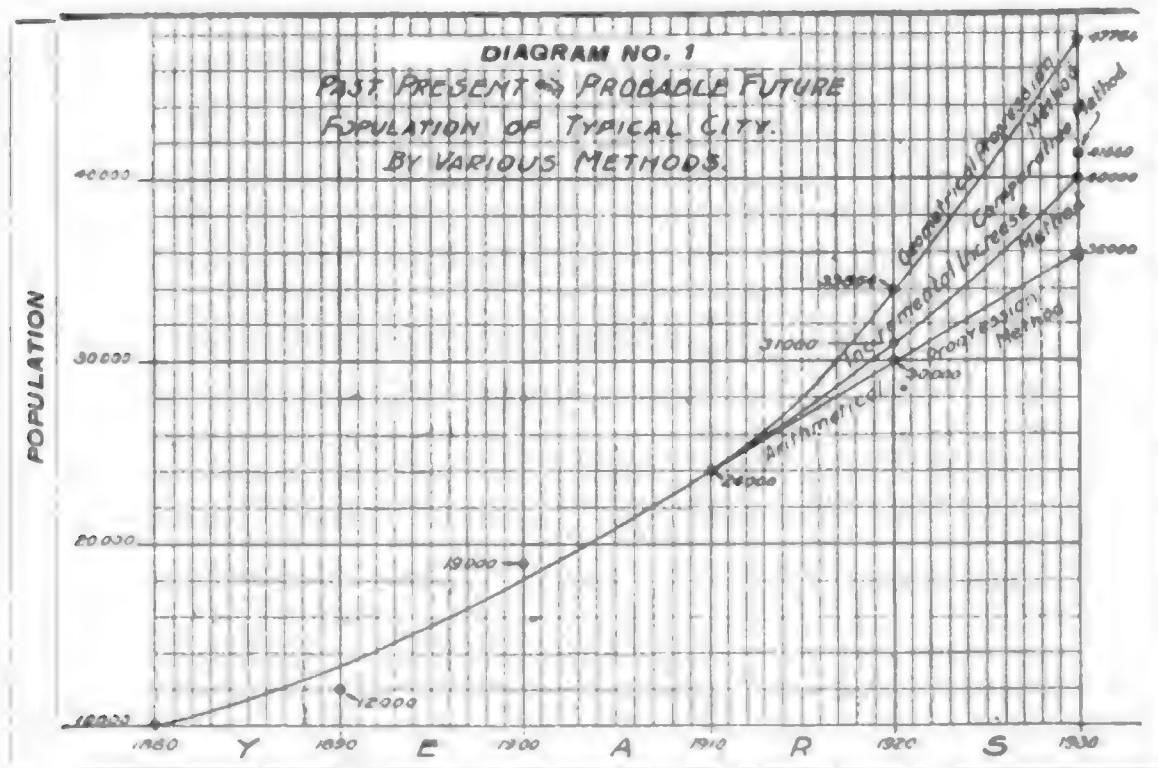
By the incremental increase method, the population of a town by decades is ascertained as far back as records have been kept. The actual gross increase in population from decade to decade is determined. Then the increase in the increase is determined, or the increment of increase for each decade. The actual increase as determined for each decade is averaged, and also the increment of increase. In making the estimates of future population, the population at the end of the first future decade is obtained by adding to the present population the average increase plus the average increment per decade thus found, and the future population at the end of the second decade by adding to the estimated population at the end of the first future decade, the average increase, plus twice the average increment, and so on.

Geometrical progression method

The geometrical progression method involves the determination of the compound rate at which the population of a city has increased in the past, then applying this compound rate to the present population, to determine the future growth.

Comparison of methods

The curves on Diagram No. 1 give the results of applying each of the four methods outlined to the population of a typical



city. The population between 1880 and 1910 as expressed by the curve is that returned by the census. The populations from 1910 to 1930 are those computed by the four methods.

It will be noted that the incremental increase method is about a mean of the several methods, and experience has shown that it frequently falls in this way in towns of normal growth. No single method, however, is applicable to all conditions and judgment must be exercised in estimating future population.

DISTRIBUTION OF POPULATION

The preceding methods are those commonly employed in estimating the future population of the community as a whole, but it

is desirable to subdivide the total population by districts in order that the size of the pipe intended to supply individual localities may be proportioned intelligently.

Whereas the commercial and manufacturing use of water and the water required for fire service are practically independent of the distribution of population, the domestic and public demand for water follows the distribution of population very closely and, therefore, a study of the distribution of population enables one to make a reasonably intelligent estimate of the probable local demands for water for the last two purposes named. After the local demand for water required for domestic and public uses has been determined through the study of population distribution, the water required for manufacturing, commercial and fire purposes in the sub-divisions used for localizing the domestic and public supply may be added from knowledge of the specific use of water for commercial, manufacturing and fire purposes in those districts.

A distribution system to be economically built must be designed to meet the conditions of some future year. In this year the distribution of population may, and usually will, be quite different from the distribution on the date of design. On the date of design some districts may be fully built up, and it would obviously be erroneous to assume that the future domestic and public water requirements in such districts will increase in the same proportion as for growing districts, or as for the city as a whole. It is possible, however, for the designer to establish a reasonable figure representing the probable density of population in any section in the city considered. He may then in apportioning the total future population by districts avoid exceeding this figure in any built up district, and by the exercise of a little judgment and with a knowledge of the local conditions, apportion the balance of the total growth to the more sparsely settled districts and thus obtain a fairly accurate future distribution of population, and hence of domestic and public water consumption.

Subdivision by wards is convenient for the purpose of apportioning local consumption in different districts and may be made without difficulty as the ward populations are usually given in the census returns.

Where ward boundaries include large areas, a further subdivision may be made, if desired, by estimating the population by registration districts. Knowing the total registration in a given city or

ward in a given year, and the population in the same year, a ratio may be established between the population and the number of registered voters. By applying this ratio to the number of registered voters in a given registration district, its population may be closely approximated. This refinement, however, is not usually necessary.

CONSUMERS

Having decided upon the probable rate of growth and distribution of future population in the territory to be supplied, it will be necessary before proceeding with estimates of domestic and public water consumption to determine the future population which will probably require to be served with water. The percentage of the total population actually connected with the public supply seldom exceeds 90 to 95 per cent, and may be much less than this, depending upon local conditions and upon the individual characteristics of the community. The desirability of basing estimates of future domestic consumption upon the probable number of water consumers, rather than upon the probable total population is, therefore, apparent.

With new installations there is usually a period of rapid growth extending over several years in which the per cent which the number of consumers bear to the total population increases rapidly from zero to a comparatively large figure. Following this development period it is not uncommon for the per cent of consumers to increase at a gradually retarded rate until 90 to 95 per cent are connected with the mains.

In designing extensions to existing systems it usually is possible to ascertain the number of consumers in present and past years, to establish the ratio between the number of these consumers and the total population, and from a study of the past in the light of knowledge of local conditions to forecast with sufficient accuracy the probable future relation between consumers and population. With this relation fixed the number of future consumers may be estimated from the previously estimated future population.

The number of actual consumers in any past year usually may be estimated most satisfactorily by ascertaining the number of service taps, or first connections, carried on the books of a company, and applying to this number a factor representing the average population per tap or per house in the community considered. In small

cities and in suburban communities this factor will usually be in the neighborhood of 5, though it may in rare instances be as low as 3, and in cities large enough to contain many apartment or tenement houses will be much greater.

The ratio between total population and the number of registered voters may sometimes be useful in determining the proper factor to use in a given community where most of the houses are occupied by not more than one family, while in the larger cities the establishment of the ratio will not be so important since in these the number of consumers will usually comprise a very large percentage of the population, and may be estimated directly.

In designing entirely new systems, the designer will be obliged to assume the probable per cent of the total population which will be served in future years, though he may be guided in forming this judgment by his knowledge of local conditions and by the values known to obtain in communities and under conditions similar to those which he has under consideration.

WATER CONSUMPTION

The next important element affecting the design of a distribution system is the average or normal quantity of water required to be delivered therethrough, and the fluctuations or variations from the normal which may be anticipated from various causes. For the sake of clearness, we will first discuss the average or normal demands and then the fluctuations which may occur.

Average or Normal Consumption of Water

The normal water consumption may be divided into four components:

- a. Domestic consumption.
- b. Water required for municipal and public purposes, including fire service.
- c. Industrial and commercial use.
- d. Water unaccounted for.

The relative importance of each component varies widely with the character and size of a community. In small villages the quantity of water required for domestic use, as compared with the quantity which the mains must deliver in time of fire, will be so small as to be almost negligible. In large cities, the reverse will be true,

while in some places the requirements for railroad or industrial uses may greatly outweigh the ordinary domestic and fire service requirements. These facts are well illustrated by Table No. 2. The maximum of the several demands may occur simultaneously, or the maximum of one or more may coincide with the minimum or average of one or more of the others.

TABLE No. 2

Relation between commercial and industrial consumption; water consumed for domestic and public purposes and wasted; and maximum fire demands in various communities

YEAR TO WHICH DATA APPLIES	COMMUNITY	POPULATION	TOTAL	RATE OF CONSUMPTION PER CAPITA					
				DOMESTIC AND PUBLIC PUR- POSES AND WASTE		COMMERCIAL AND INDUS- TRIAL		MAXIMUM FIRE DEMAND FREEMAN'S MINIMUM	
				Gallons daily	Percent of total	Gallons daily	Percent of total	Gallons daily	Percent of total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1906	East Green- wich, R. I.	3,750	68.6	30.4	44.3	38.2	55.7	384.0	559.0
1906	Patchogue, L. I.....	3,800	112.0	43.0	38.4	69.0	61.6	384.0	342.8
1909	Rochester and Lake Onta- rio Water Company..	7,100	420.2	113.4	27.0	306.8	73.0	253.0	60.2
1913	Woodhaven, L. I.....	30,000	66.5	57.9	87.1	8.6	12.9	120.0	180.4
1911	Jamaica, L. I.	42,000	95.9	88.8	92.6	7.1	7.4	103.0	107.4
1908	Boston, Mass ¹	643,810	153.0	125.3	81.9	27.7 ²	18.1	35.8	23.4

¹ *Journal New England Water Works Association*, Vol. 27, No. 1, p. 102.

² Meter only.

Domestic Consumption

The quantity of water required for domestic purposes is a function of the number of consumers, although very marked differences are observable in different communities in the actual consumption of water per consumer for domestic purposes, which, after making all due allowance for the presence or absence of meters, are indicative of marked characteristic demands in the individual community for the legitimate use of water for domestic purposes.

Table No. 3 gives in column 5, the domestic consumption of water per consumer per day in various places. The figures as given have

TABLE No. 3

Data relating to consumption of water for domestic and public purposes

NAME OF PLACE OR COMPANY	TOTAL POPULATION CENSUS OF 1910	NUMBER OF DOMESTIC SERVICES MEASURED	ESTIMATED NUMBER OF DOMESTIC CONSUMERS MEASURED	DOMESTIC CONSUMP- TION GALLONS DAILY PER CONSUMER	FREE CON- SUMPTION PUBLIC PURPOSES, GALLONS DAILY PER CAPITA
(1)	(2)	(3)	(4)	(5)	(6)
Massachusetts:					
Metropolitan Water Dis- trict of Boston.....	1,022,230		53799	33.0	7.11
Brockton ¹	56,878			15.5	3.00
Brookline.....	27,792				13.05
Chelsea.....	32,452		13937	26.1	
Everett.....	33,484		395	33.1	
Fall River.....	119,295				12.79
Lawrence ²	85,892			17.0	5.00
Malden.....	44,484		37994	17.6	
Quincy.....	32,642		8391	25.6	
Revere.....	18,219		938	36.6	
Somerville.....	17,236		26234	25.6	
Swampscott.....	6,204		2871	34.7	
Watertown.....	12,875		11299	16.7	
Worcester.....	145,986		3716	44.0	
Rhode Island:					
East Greenwich.....	3,420		3420	30.4	
Woonsocket.....	38,125				5.57
Connecticut:					
Hartford ²	98,915			30.0	5.00
New York:					
Canandaigua.....	7,217				12.25
Elmira.....	37,176	2124	12107	19.6	
Geneva.....	14,000	2481	12500	20.0	
Patchogue.....	3,824		3824	43.0	
Syracuse ³	137,249			31.0	18.00
Yonkers.....	79,803			20.0	5.00
New Jersey:					
East Orange.....	34,371	3545	18350	58.5	2.00
Montclair.....	24,426			35.0	
Pennsylvania					
Harrisburg ³	64,186			30.0	5.00
Pennsylvania Water Co....		2000	10000	21.4	

¹ Report of Water Board, 1904.² Journal of N. E. W. W. Ass'n., March, 1913.³ Superintendents' Estimate.⁴ Local Estimate.

TABLE No. 3—Continued

NAME OF PLACE OR COMPANY	TOTAL POPULATION CENSUS OF 1910	NUMBER OF DOMESTIC SERVICES MEASURED	ESTIMATED NUMBER OF DOMESTIC CONSUMERS MEASURED	DOMESTIC CONSUMP- TION GALLONS DAILY PER CONSUMER	FREE CON- SUMPTION PUBLIC PURPOSES. GALLONS DAILY PER CAPITA
(1)	(2)	(3)	(4)	(5)	(6)
<i>Pennsylvania—Continued</i>					
Pittsburgh.....	533,905	390	1950	35.0	
Vicinity of Pittsburgh.....		4801	24005	23.0	
Six Other Places in Vicinity of Pittsburgh.....		17222	86110	20.0	
<i>Ohio:</i>					
Cincinnati.....	363,591	8245	65960	58.8	7.00
<i>Illinois:</i>					
Peoria.....	66,950		744	52.0	
<i>Louisiana:</i>					
New Orleans.....	339,075			35.0	

been obtained from different sources and largely from the Report of the Committee on Water Consumption of the New England Water Works Association as published in the *Journal* of that Association for March, 1913. It is seen from the table that the per consumer consumption of water for domestic purposes in the places listed varies between 15.5 gallons and 58.5 gallons, or by about 360 per cent. It is important that a designer bear this fact in mind and not attempt to force town A to struggle along on 20 gallons per capita for domestic consumption because town B, a thousand miles away, is able to do so.

Water Required for Municipal and Public Purposes

The water required for free public purposes is also given on the preceding table and varies between 2 and 18 gallons daily per capita. Probably an average allowance of 10 gallons daily per capita will be safe in providing for a new system of mains or for reinforcements to an existing system. Although the quantity of water required for these purposes is more properly a function of the total population in the territory supplied than of the number of water consumers in that territory, in most instances no serious error will be introduced by estimating it on the basis of the number of gallons daily required per consumer.

The water consumed for fire purposes is included in the amounts given for free public purposes, but to consider the requirements for fire fighting as a percentage of total consumption, or in gallons per capita or per consumer is grossly misleading for the reason that this fire service comes as a peak load, at long intervals and lasting for but short periods. When these peak loads occur, the demands for fire service may and do, in small communities, represent a quantity often as great, or greater than, the total average daily demand for water, so that special estimates must be made for the purpose of determining the maximum fire draft under given conditions in order properly to design the distribution system. Such estimates fall in the category of fluctuations rather than average demand, and will be estimated separately.

Industrial and Commercial Use

So far as the industrial and commercial consumption is concerned, the ratio of the demand for this purpose to the total demand varies so radically in different places, depending upon the extent of the commercial and industrial interests, that it is not possible to give figures representing a proper allowance for it. It is necessary, in each individual instance, to determine the amount of water at present used for such purposes. This is one of the unknown factors that can be ascertained only by a local survey. The range of consumption for industrial and commercial purposes is from zero in suburban residential districts to 80 or 100 gallons per capita in large manufacturing centers where the processes employed create a heavy demand for water. Even after the present quantity of water used for industrial and commercial purposes has been ascertained by survey there will remain the difficulty of forecasting what this quantity will be in the future as the growth in these requirements frequently bears a rather indefinite relation to the growth of population. It may sometimes be desirable, especially in the case of railroads and of very large industrial concerns, to make individual forecasts of their future needs, basing the judgment upon knowledge of local conditions, inquiries made of the owners or officers of the various companies, etc. In many instances, however, it will be safe to assume that the growth in the requirements of existing industrial and commercial concerns will increase in the same ratio as the population.

In whatever way the future needs of these existing concerns is estimated, some additional allowance should be made for plants which are not extant at the date of the design.

In some instances it may be necessary to take account of the manner in which the daily railroad, industrial and commercial use of water is distributed over the twenty-four hours. If an industrial plant using 500,000 gallons of water per day operates only twelve hours out of the twenty-four, its effective consumption, so far as the required main carrying capacity is concerned, will be at the rate of 1,000,000 gallons per day. As was the case with the fire service flows, however, these estimates fall in the category of fluctuations rather than of average demand and should be estimated separately.

Water Unaccounted for

The water unaccounted for includes that wasted. The water wasted varies materially in different communities, probably, in general, between the limits of 20 per cent and 40 per cent of the total water supplied. The water unaccounted for and wasted may be divided into:

<i>Metered Supplies</i>	<i>Unmetered Supplies</i>
1. That unaccounted for through measurement by plunger displacement of pumps where no allowance is made for slip.	1. That unaccounted for through measurement by plunger displacement of pumps where no allowance is made for slip.
2. That lost through leaky mains and services.	2. That lost through leaky mains and services.
3. That unaccounted for through under-registration of meters.	3. That lost through defective plumbing and house piping.

The pump slippage is a variable quantity, varying from 3 per cent in the best type of pumps which are well maintained, to 65 per cent in pumping engines which are not properly cared for. It is exceedingly common to find a slippage of 10 to 20 per cent in the ordinary pumping station.

The loss of water through mains and services depends upon the care and skill with which the distribution system was installed, the amount of attention which is given to the maintenance of the dis-

tribution system, and upon the relation of main mileage to the total consumption. In general, it may be said to vary between 15 per cent and 30 per cent of the total consumption.

Table No. 4 gives the results of leakage tests on carefully laid cast iron pipe from 4 inches to 36 inches in diameter. It indicates that an average main leakage of 100 gallons per mile per inch of diameter may be expected even in new and unusually well constructed systems. In a system containing 100 miles of pipe averag-

TABLE No. 4

Results of leakage tests on cast iron pipe

CITY	SIZE OF PIPE INCHES	LENGTH OF PIPE TESTED FEET	NUMBER OF TESTS MADE	AVERAGE LEAKAGE GALLONS DAILY PER MILE PER INCH OF DIAMETER	PRESSURE UNDER WHICH TEST WAS MADE POUNDS
(1)	(2)	(3)	(4)	(5)	(6)
Akron, Ohio	4	717	1	23	66 to 152
Reported by E. G. Brad-	6	31,066	34	66	66 to 152
bury, <i>Engineering Record</i> ,	8	6,882	6	42	66 to 152
Volume 65, page 432	10	5,123	5	81	66 to 152
	12	9,704	8	102	66 to 152
	16	8,792	11	135	66 to 152
	20	8,389	10	60	66 to 152
	24	3,358	3	69	66 to 152
	30	14,445	8	82	66 to 152
Total or Average		88,476	86	83.4	66 to 152
Columbus, Ohio	36	16,940	3	422	110
Reported by J. H. Gregory, <i>Engineering News</i> , Volume 72, page 725					

ing 8 inches in diameter this would mean a minimum leakage from mains alone of 80,000 gallons daily, or possibly 5 per cent of the total consumption. In the average system it will be considerably more than this.

Table No. 5 fairly illustrates the water unaccounted for in cities having metered supplies.

An allowance of from 3 to 6 per cent should be made for under registration of meters.

23600

TABLE No. 5

Water unaccounted for in cities with metered supplies

CITY	PER CENT METERED	WATER UNACCOUNTED FOR	
		PER CENT	GALLONS PER DAY PER MILE OF PIPE
(1)	(2)	(3)	(4)
Attleboro, Mass.....	(a) 100	53.0	—
Brockton, Mass.....	90	32.3	6,200
Fall River, Mass.....	96	21.5	10,000
Harrisburg, Pa.....	(b) 75±	21.0	—
Hartford, Conn.....	(b) 99	39.0	—
Lawrence, Mass.....	(b) 87	29.0	—
Madison, Wis.....	(a) 97	69.0	—
Needham, Mass.....	(a) 95	75.0	—
North Attleboro, Mass.....	(a) 100	55.0	—
Providence, R. I.....	90	30.0	13,400
Ware, Mass.....	100	39.8	11,200
Watertown, Mass.....	(a) 94	47.0	—
Wellesley, Mass.....	100	41.5	3,450
Winchendon, Mass.....	(a) 97	55.0	—
Woonsocket, R. I.....	87	23.0	4,370
Worcester, Mass.....	94	46.5	20,800
Yonkers, N. Y.....	100	45.7	23,340

(a) Data obtained from Table No. 11, p. 136, *Journal New England Water Works Association*, 1907. Paper by W. S. Johnson.

(b) Data obtained from Report of Mr. James H. Fuertes to Merchants Association, New York, 1906.

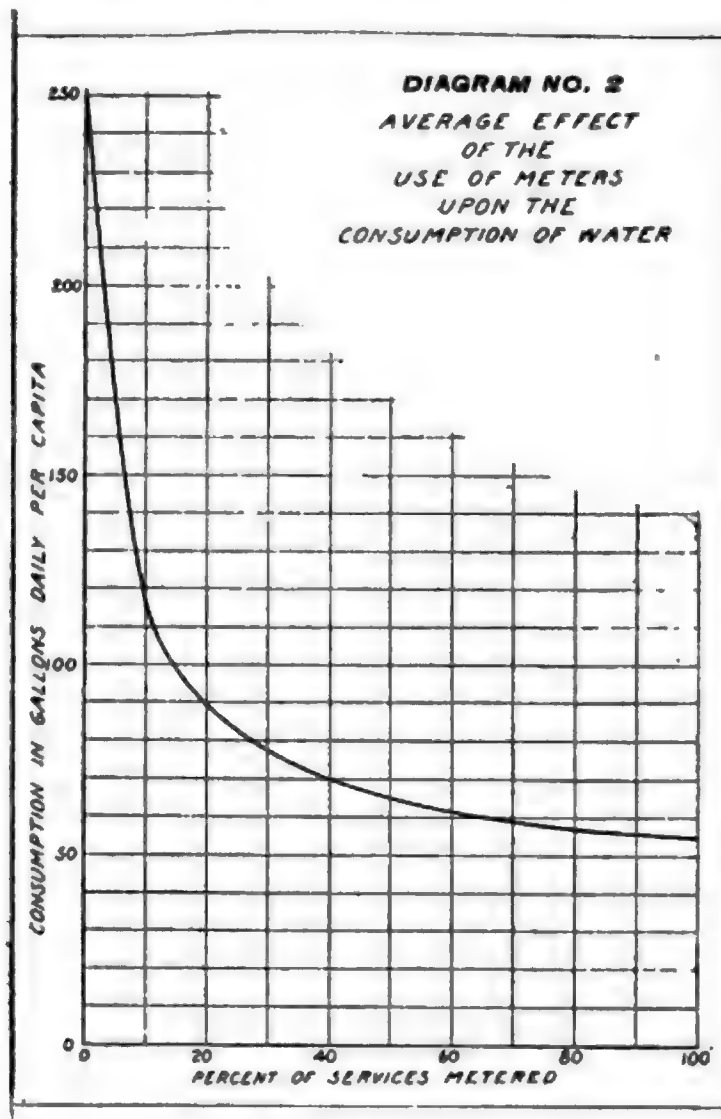
Allowances for the probable quantity of water which will be unaccounted for or wasted in future years may usually be estimated most conveniently as a certain number of gallons per capita or per consumer, the number being based upon present values where ascertainable with due regard for steps which may be taken to reduce existing leakage and waste. The reasonableness of the assumptions thus made should always be checked by calculating what they represent in per cent of total consumption and per mile of pipe.

Effect of Meters in Reducing Waste

The possible reduction of losses due to defective plumbing and to other household waste by the introduction of meters depends upon the care and system with which house-to-house inspections have been made prior to the introduction of meters, as well as upon

the general condition of plumbing which varies greatly in different sections, upon the habits of the people, and in a measure upon climatic conditions.

It is not possible to give a specific statement of the saving which may be effected by meters in a particular community without a deliberate local study. As a general indication of the effect of the



introduction of meters, however, Diagram No. 2, taken from Mr. John R. Freeman's *Report on New York's Water Supply* is presented.

It is dangerous to be too hopeful about the prevention of waste, for, with these hopes unfulfilled and an insufficient distribution system, pressures will be reduced below the point required for satisfactory service.

While the general introduction of domestic meters will usually

result in curtailing household waste, it is inexcusable to place too much reliance upon this expedient while local sentiment is against the domestic meter, and it is poor policy to provide an insufficient distribution system while discussing what ought to be done to educate the public to a greater economy in the use of water.

In providing for the health, comfort, convenience and future prosperity of a community, the engineer must be governed by practical considerations; by what the public will do and not by the theory of what they ought to do; by the efficiency ordinarily attained in municipal departments and not that which should be attained. From the operating and economic viewpoint, waste should be fought and fought hard. Its restriction saves capital outlay for enlarged mains, pumps, filters and reservoirs. It saves operating costs for fuel, coagulants, supplies and labor. A standard of reasonable consumption should be set and its attainment constantly aspired to. From the viewpoint of future requirements, however, sufficient main capacity must be provided so that, under normal conditions, with things and men as we find them, no one shall suffer by reason of his neighbor's waste or the inefficiency of municipal departments. It is well to estimate upon the proper, theoretical, economical per capita consumption as a minimum, and to estimate the future consumption as a reasonably conservative maximum. Nothing will be lost by this, so far as the distribution system is concerned, for the reason that it means only that the mains will have a life of a few years more before replacements or reinforcements are required, and figured on this basis, it matters very little so far as the financial return is concerned whether the pipes as laid are estimated to be large enough for twenty or for twenty-five years.

Effect of Sewers upon Consumption

The presence or absence of sewers will exert a material influence upon the average quantity of water consumed.

Table No. 6 which was obtained from the report of the Committee on Water Consumption previously referred to, gives the average consumption of water in three Massachusetts cities before and after the introduction of a fairly complete system of sewers. As in the case of the introduction of meters, it is not possible to give exact figures representing the probable changes in the use of water

TABLE No. 6

Average consumption of water in three Massachusetts cities before and after the introduction of a fairly complete system of sewers

Gallons per person per day

CITY	YEARS PREVIOUS TO INTRODUCTION OF SEWERS							YEAR WHEN SYSTEM OF SEWERS WAS PRACTICALLY COMPLETED (1891)	YEARS SUBSEQUENT TO INTRODUCTION OF SEWERS																
	7	6	5	4	3	2	1		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Marlborough.	13	17	20	21	24	24	25	26	30	30	35	34	37	37	38	38	36	37							
Newton.	28	31	33	33	31	36	40	43	50	52	60	65	63	60	57	63	62	63							
Waltham.....	37	36	39	33	31	32	33	40	47	53	61	59	71	70	76	88	90	88							

which will result from the introduction of sewers in a specific place, but the table illustrates, in a general way, that where a system is being designed for a town without sewers, liberal allowance should be made for the subsequent introduction of sewers.

Variations in Average Per Capita Consumption

The total consumption of water in cities and towns varies between wide limits, as is indicated by Table No. 7 and it is necessary for the engineer in designing a system of distribution to study the local and characteristic uses.

TABLE No. 7

Total consumption of water in various metered and unmetered cities in the eastern United States

CITY	POPULATION	DAILY CONSUMPTION	DAILY CONSUMPTION PER CAPITA
(1)	(2)	(3)	(4)
<i>Connecticut:</i>			
Bridgeport.....	112,144	22,428,800	200
Hartford.....	126,582	8,640,000	68
Meriden.....	28,228	2,822,800	100
New Haven.....	141,915	21,287,250	150
New London.....	20,000	3,104,947	155
Stamford.....	28,106	4,215,900	150
Waterbury.....	80,289	7,282,213	91

TABLE No. 7—Continued

CITY	POPULATION	DAILY CONSUMPTION	DAILY CONSUMPTION PER CAPITA
(1)	(2)	(3)	(4)
<i>New York:</i>			
Albany.....	102,344	22,486,000	220
Auburn.....	36,071	6,542,189	182
Binghamton.....	51,300	7,242,286	140
Brooklyn.....	1,786,327	157,500,000	91
Buffalo.....	446,889	138,100,000	309
Elmira.....	37,664	4,970,000	132
Ithaca.....	15,000	2,000,000	133
Kingston.....	26,354	6,994,821	266
Middletown.....	15,570		
Newburgh.....	28,733	4,128,931	144
New York (Manhattan).....	2,487,962	303,000,000	104
Oswego.....	23,747	4,650,064	196
Poughkeepsie.....	29,203	2,715,879	93
Rochester.....	235,968	22,180,992	94
Schenectady.....	86,305	10,615,515	123
Syracuse.....	146,480	17,577,600	120
Troy.....	77,382	21,000,000	271
Yonkers.....	90,156	8,679,915	96
<i>New Jersey:</i>			
Atlantic City.....	52,098	12,785,000	245
Camden.....	100,581	12,572,625	125
Elizabeth.....	80,272	13,164,608	164
Jersey City.....	287,709	44,882,607	156
Newark.....	379,211	38,679,522	102
Passaic.....	63,542	4,575,024	72
Plainfield.....	22,231	3,440,000	150
Trenton.....	104,451	20,000,000†	191 ±
<i>Pennsylvania:</i>			
Allegheny.....	140,200	35,134,120	251
Altoona.....	55,504	5,200,000	94
Bradford.....	17,000	2,000,000	117
Erie.....	71,004	11,050,537	153
Johnstown.....	62,705	10,032,800	160
Lancaster.....	49,101	5,900,000	120
Norristown.....	29,697	2,375,760	80
Philadelphia.....	1,631,956	290,500,000	178
Pittsburgh.....	385,100	84,991,570	221
Reading.....	101,628	13,923,036	138
York.....	48,318	3,160,000	66

Even in places where a large percent of the services are metered, the variation in per capita consumption is very great. This is indicated by Table No. 8. It will be noted that with a single exception, none of the towns listed in this table, has less than 70 per cent of the services metered, yet the gross per capita consumption varies between 38 and 128. The table is presented to accen-

TABLE No. 8

Variations in total per capita consumption of water in plants having a large percentage of metered services

CITY	PER CENT METERED SERVICES	TOTAL CONSUMPTION GALLONS PER CAPITA
(1)	(2)	(3)
Anniston, Alabama.....	76	128
Atlanta, Georgia.....	100	65
Bayonne, New Jersey.....	100	95
Bessemer, Alabama.....	70	46
Brockton, Massachusetts.....	90	38
Cleveland, Ohio.....	94	100
Consolidated Water Company.....	85	71
Covington, Kentucky.....	100	51
Geneva, New York.....	91	35
Harrisburg, Pennsylvania.....	83	122
Hartford, Connecticut.....	98	68
Lexington, Kentucky.....	98	58
Lincoln, Nebraska.....	100	40
Milwaukee, Wisconsin.....	99	105
Montclair, New Jersey.....	100	66
Newton, New Jersey.....	86	58
New York Inter Urban Water Company.....	95	78
Passaic, New Jersey.....	54	72
Providence, Rhode Island.....	90	68
Rochester and Lake Ontario Water Company.....	100	94
Utica, New York.....	98	59
Yonkers, New York.....	100	96

tuate the caution which must be observed in making reasonable allowance for local characteristics in estimating the probable required consumption for a given community.

An analysis of the distribution of consumption in individual locations will often afford a reasonable explanation for the great variation in per capita consumption. It will be found that the industrial and commercial uses are large in one place, or that the

character of the population in another place is such as to exact a liberal supply of water. In suburban places, large quantities of water are used for lawn sprinkling, more than is generally appreciated.

Progressive Increase in Normal Per Capita Demand

The history of nearly every American city shows that the per capita consumption of water increases as the population increases. In Rochester, New York, where the water department has been conducted along the best lines for years, the per capita consumption increased from 60.2 gallons, in 1879, to 86.6 gallons, in 1907, while during the same period the number of metered services increased from 2 per cent to 70 per cent.

Notwithstanding the efforts which have been made to lessen the quantity of water consumed in Baltimore, the per capita consumption increased from 72 gallons, in 1880, to 120 gallons, in 1909, and this is smaller than in most of the large American cities.

The per capita consumption in the city of Cleveland, in 1874, was 45.36 gallons per day, with 1.28 per cent of the connections in use metered and, in 1908, with 93.61 per cent of the connections metered, the per capita consumption was 100.3 gallons.

These examples may tend to discredit the meter in the minds of laymen. This is not the intention. The City of Cleveland, while illustrating the natural tendency to an increased per capita consumption also illustrates the economy which will result from the introduction of meters. In 1901 the per capita consumption had increased to 169.4 gallons, with 6.42 per cent of service connections metered and the reduction from 169 gallons per capita, represents the saving which resulted from an extended use of meters and proper water waste prevention. Had the per capita consumption continued to increase, as formerly, the present rate would be over 200 gallons per day.

That the presence of meters does exert a marked retarding effect upon the growth of per capita consumption is clearly indicated by the two accompanying diagrams, 3 and 4.

In planning the Boston Metropolitan supply, about fifteen years ago, a very careful investigation was made of the probable requirements of that city, by Mr. Dexter Brackett, now chief engineer, who, at that time, had acquired a large experience in water waste

DIAGRAM NO. 3

FLUCTUATIONS IN THE PER CAPITA USE OF WATER

IN CITIES HAVING LESS THAN
15% OF SERVICES METERED

SMALL FIGURES INDICATE PER CENT OF SERVICES METERED

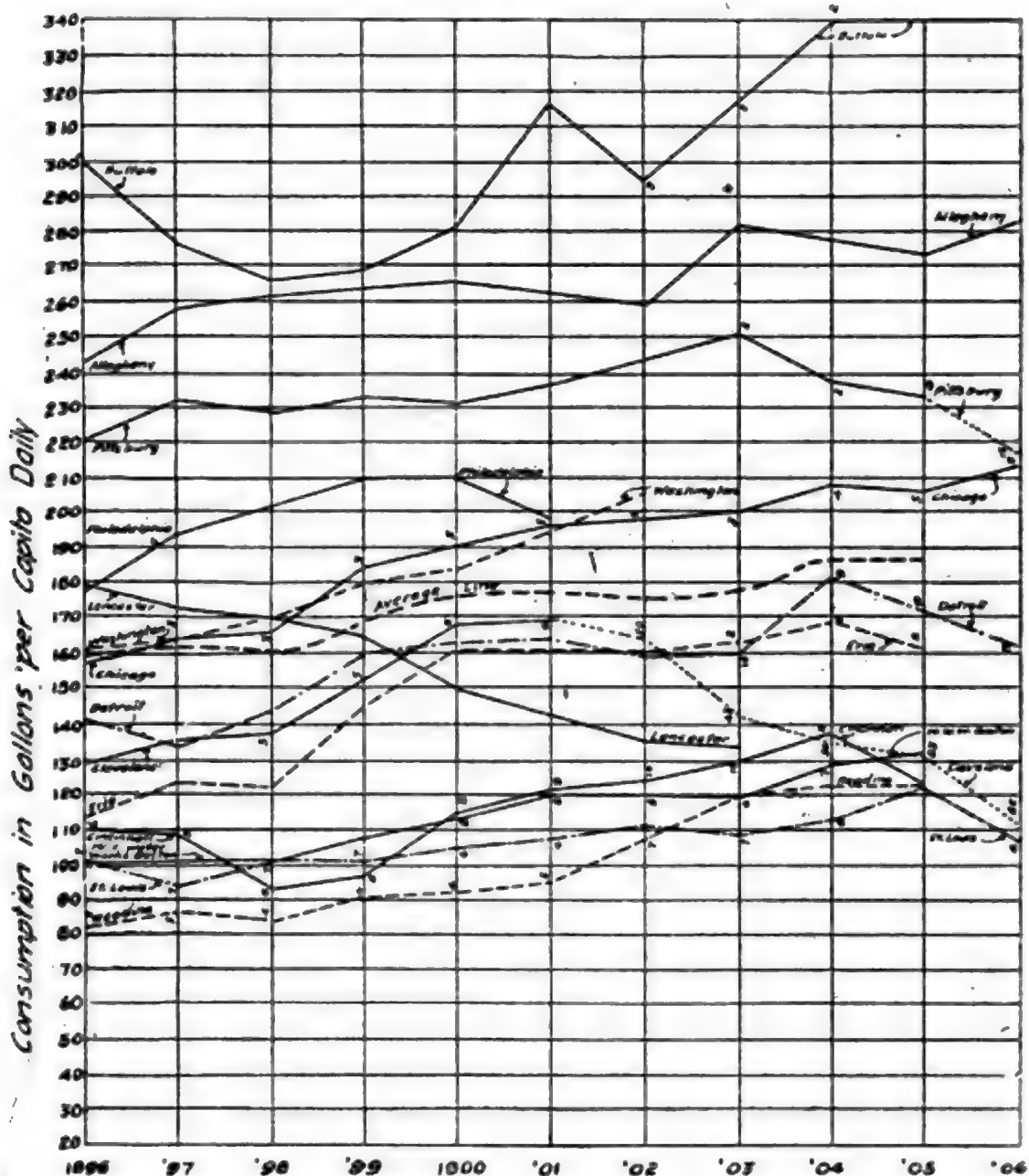
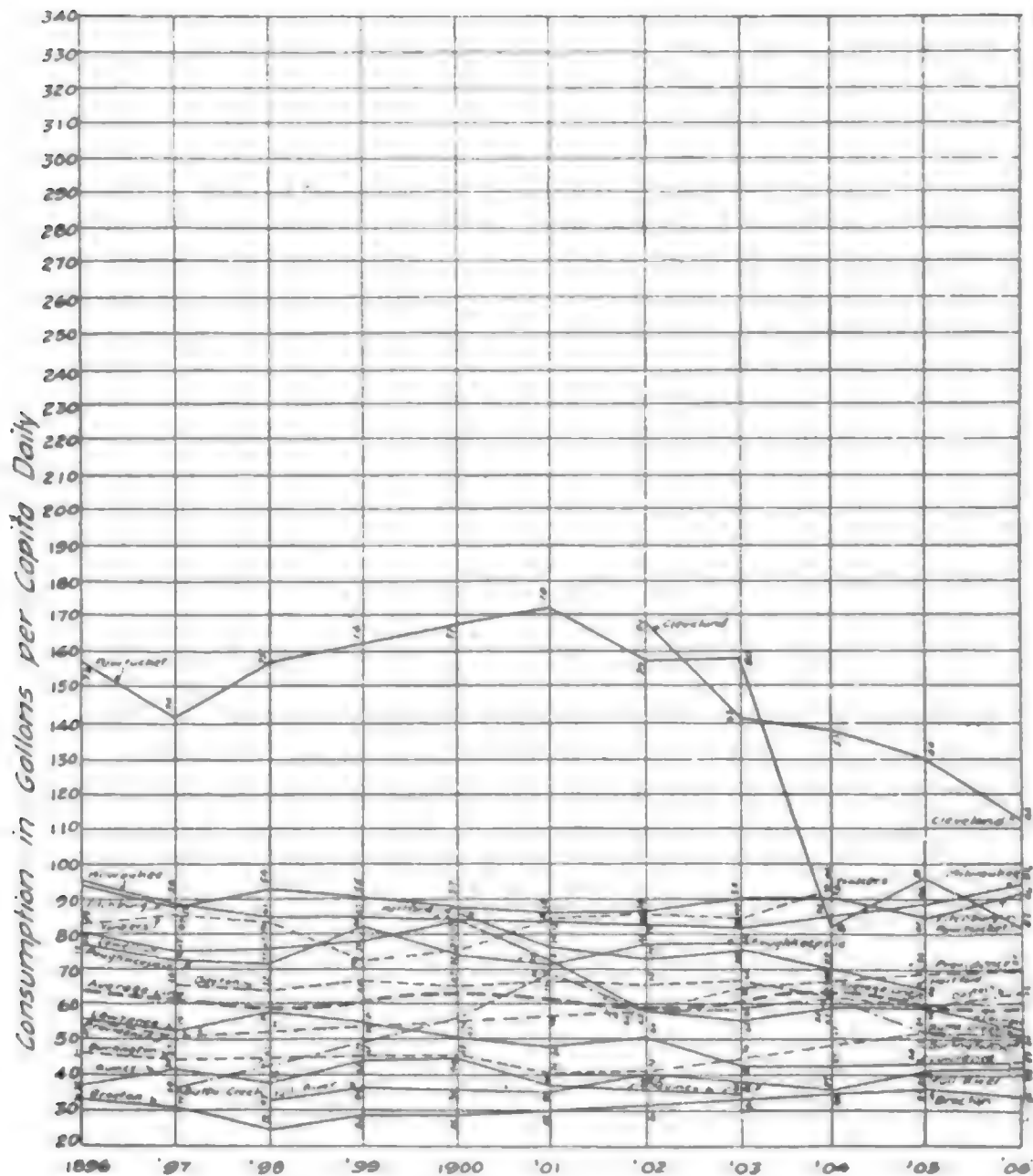


DIAGRAM NO. 4

FLUCTUATIONS IN THE PER
CAPITA USE OF WATERIN CITIES HAVING MORE THAN
50% OF SERVICES METERED

SMALL FIGURES INDICATE PER CENT OF SERVICES METERED



prevention. He estimated the suitable allowance for the Boston Metropolitan District, to be:

	<i>Gallons per Capita</i>
For domestic use.....	35
For trade and mechanical purposes.....	35
For public use.....	5
Waste.....	25
Total.....	100

The per capita consumption of water in the Metropolitan District has been as high as 128 gallons per day.

In March, 1906, a careful investigation for the extension and betterment of the Cincinnati Water Works was made by three eminent engineers. After carefully considering the conditions in Cincinnati and other representative cities and assuming that an earnest effort to prevent unnecessary waste would be made at Cincinnati, estimates of the future requirements were based on an average consumption of 130 gallons per capita per day.

The Commission on Additional Water Supply for the City of New York, after reviewing the results of water waste investigations conducted by the writer, decided that the greatest possible saving to be effected by reducing the waste and by decreasing the extravagant use of water, would not provide for more than a few years to come, and based its estimates of the future requirements, which additional works would be called upon to provide, on 150 gallons per day for each member of the population.

In a recent estimate of the probable future requirements of water in Baltimore, made preparatory to plans for a new and additional supply, the engineers decided that it was not prudent to plan new works on the assumption of a smaller per capita use than 130 gallons per capita in 1915; 135 gallons per capita in 1920; 145 gallons per capita in 1930; 150 gallons per capita in 1940.

In estimating probable future demands for water it is advisable where possible to ascertain accurately the amount of water which has been used in the past in the community under consideration, to subdivide the uses of this water as far as possible and, if practicable, to fix upon the probable amount of waste. Then, having determined the total waste, an estimate of waste which would be remediable with the exercise of ordinary care and supervision may be made and the proper correction applied. It is also advisable to check

the local consumption of water with the consumption of towns of like population, location, environment and other characteristics, to see whether the total consumption in the community considered indicates abnormality.

Fluctuations in Consumption

The preceding values for per capita consumption are all averages for the year, and may be exceeded for periods of considerable length.

At the outset of a discussion of the fluctuations in consumption which are noticeable in all water works systems, and must be properly provided for, attention should be called to the fact that differentiation must be made between the fluctuations which occur in a metered and in an unmetered system. The presence of meters introduces a marked levelling effect upon the fluctuations which occur from various causes and, therefore, their presence has a decided effect on the reduction of the peak loads which must be met by a distribution system in an unmetered city. The saving in fixed investment in distribution system due to this levelling effect is not generally appreciated, but must be borne in mind if the best economy is to be obtained in the design.

It is exceedingly difficult to apply the fluctuations which occur in one community to another community, and as portable instruments, such as the pitometer, which are inexpensive and easy to use, are available, actual measurements of the fluctuations to be met in a given place should be made prior to the re-design of a distribution system, where the data available are not sufficient for the purposes at hand.

The daily consumption will frequently be considerably higher than the average during cold winter months due to the opening of bibb cocks to prevent freezing in the mains and service connections. It will frequently be higher than the average in the summer due to lawn and street sprinkling and to the more liberal use of water for bathing purposes. It will be affected, though in a smaller degree, by less marked fluctuations in the temperature of the air, and the amount of rainfall during the summer will produce its effect.

The daily consumption in some communities will be much higher on Mondays and Tuesdays when domestic washing is being done than on Saturdays and Sundays.

The consumption will be much higher during the day than at

night, and will ordinarily, for obvious reasons be much higher for a few hours in the morning and late afternoon than during other hours in the day. These variations will be less marked in large communities than in small ones.

As an illustration of the fluctuations which may occur, Diagrams Nos. 5 to 11 are presented herewith which indicate the existence and extent of these variations in the places to which they apply. The figures presented by the diagrams show the fluctuations in total consumption including that used for commercial, industrial, railroad and other purposes.

Diagram No. 5 gives the variations in the average daily consumption by months in a city of 250,000 people during the year 1907 and the first four months of 1908. It will be noted that the consumption is highest in February in each year, the daily consumption in February, 1907, being 1.08 times the average daily consumption for the year.

Diagram No. 6 gives the variations in the average daily consumption by months from July, 1908, to December, 1912, inclusive in a community in which the population increased from 20,645 to 31,410 during the period covered by the record. In this community, whose average population during the period was approximately 25,000 people, the consumption is highest in July of each year, the daily consumption during July being from 1.12 to 1.20 times the average daily consumption for the year. On this diagram is also noted the consumption during the absolute maximum day of each year. In all but one instance, this maximum day occurs during the maximum one month, and varies from 1.5 to 1.95 times the average daily consumption for the year.

Diagram No. 7 shows the hourly fluctuations in consumption as measured by pitometer in a community of 5,000 people. The record, covering several days, also illustrates well the variations in the daily consumption on different days of the week. It shows an hourly rate of consumption varying from 0.35 to 1.86 times the average rate during the day on which the maximum hour as shown occurred.

Diagrams Nos. 8 to 11, inclusive, show the annual, monthly, daily, and hourly variations in consumption at Auburn, New York, which has about 9 per cent of the service taps metered.

Diagram No. 8 shows the monthly variations in the total average daily consumption from 1892 to 1912 inclusive, also the progressive

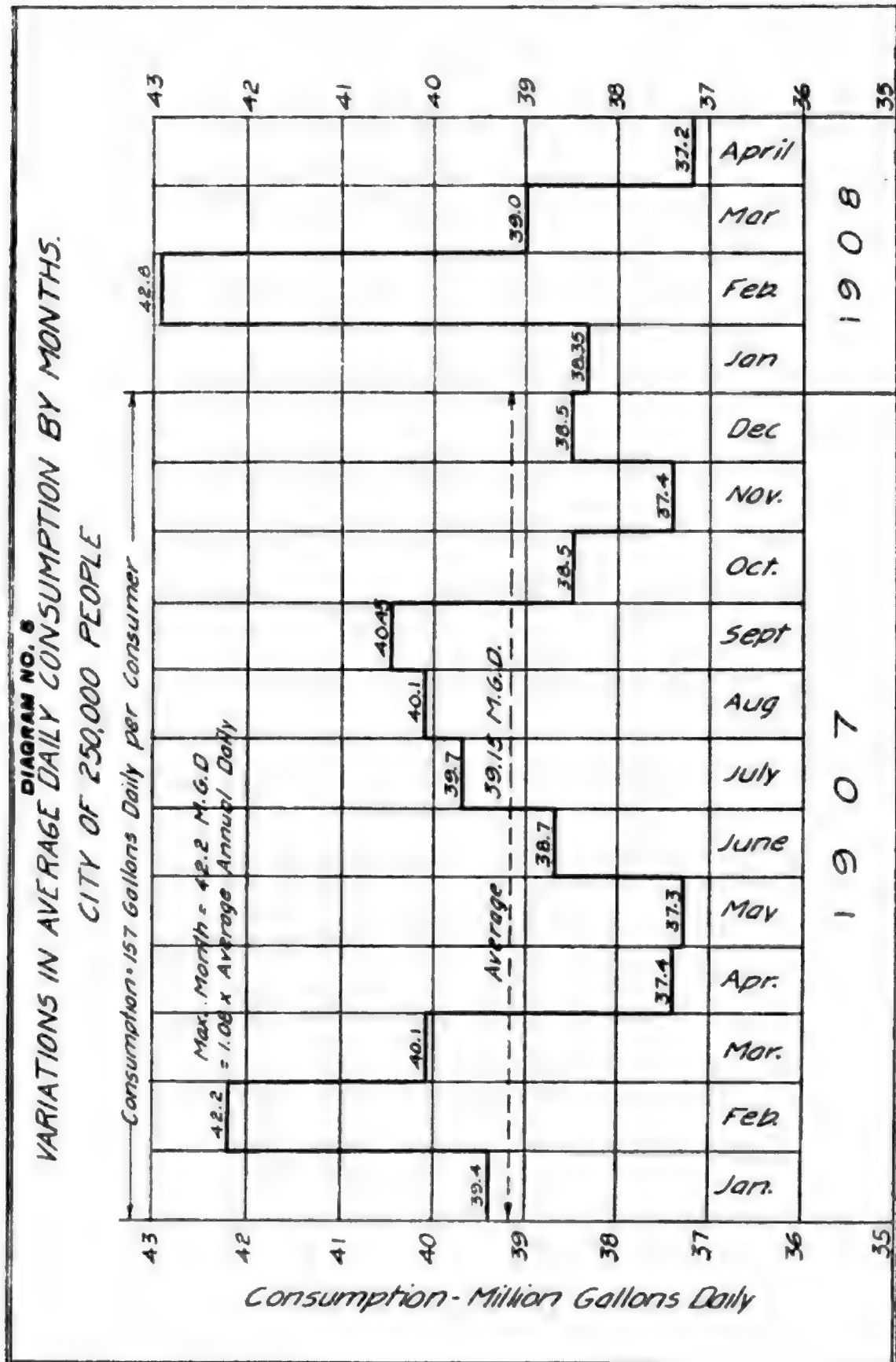


DIAGRAM NO. 8

VARIATIONS IN AVERAGE DAILY CONSUMPTION BY MONTHS.
CITY OF 20,000 TO 30,000 PEOPLE.
(3.12 METERED)

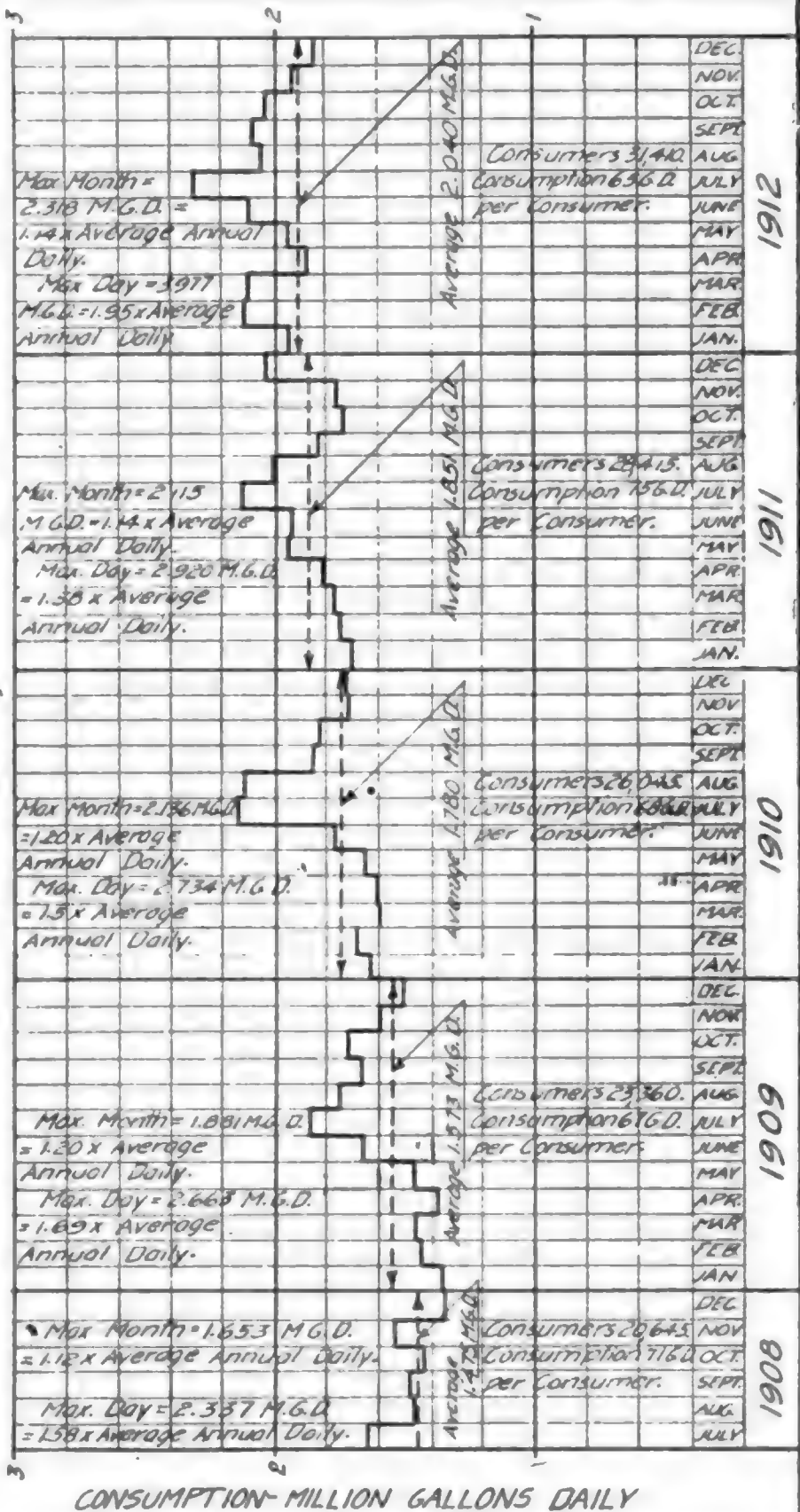


DIAGRAM NO. 7
 VARIATIONS IN DAILY CONSUMPTION BY HOURS
 COMMUNITY OF 5000 PEOPLE (UNMETERED)

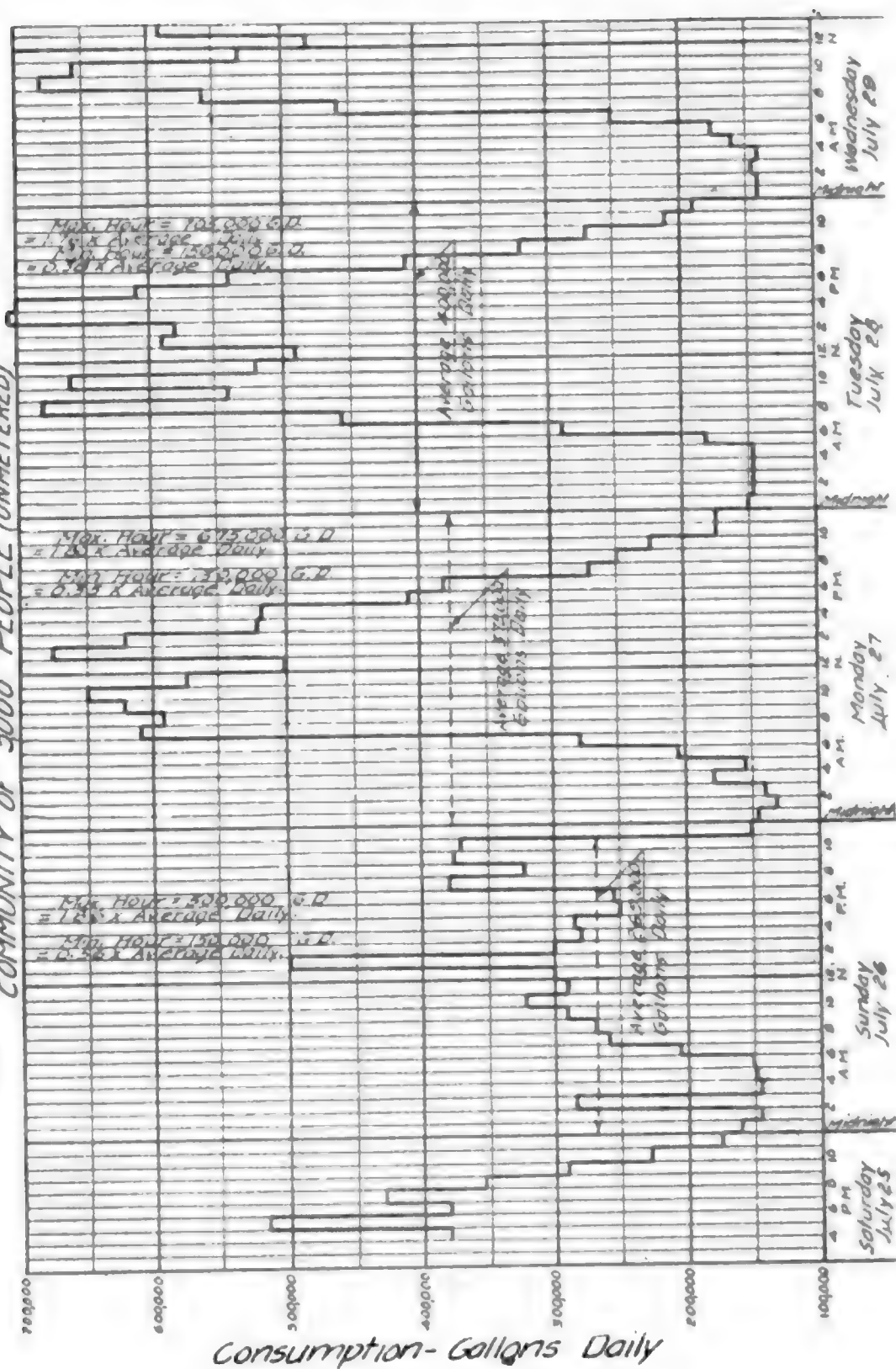


DIAGRAM NO. 8
AVERAGE MONTHLY CONSUMPTION
CITY OF AUBURN, N. Y.
1892 POPULATION = 25,000
1912 POPULATION = 36,000

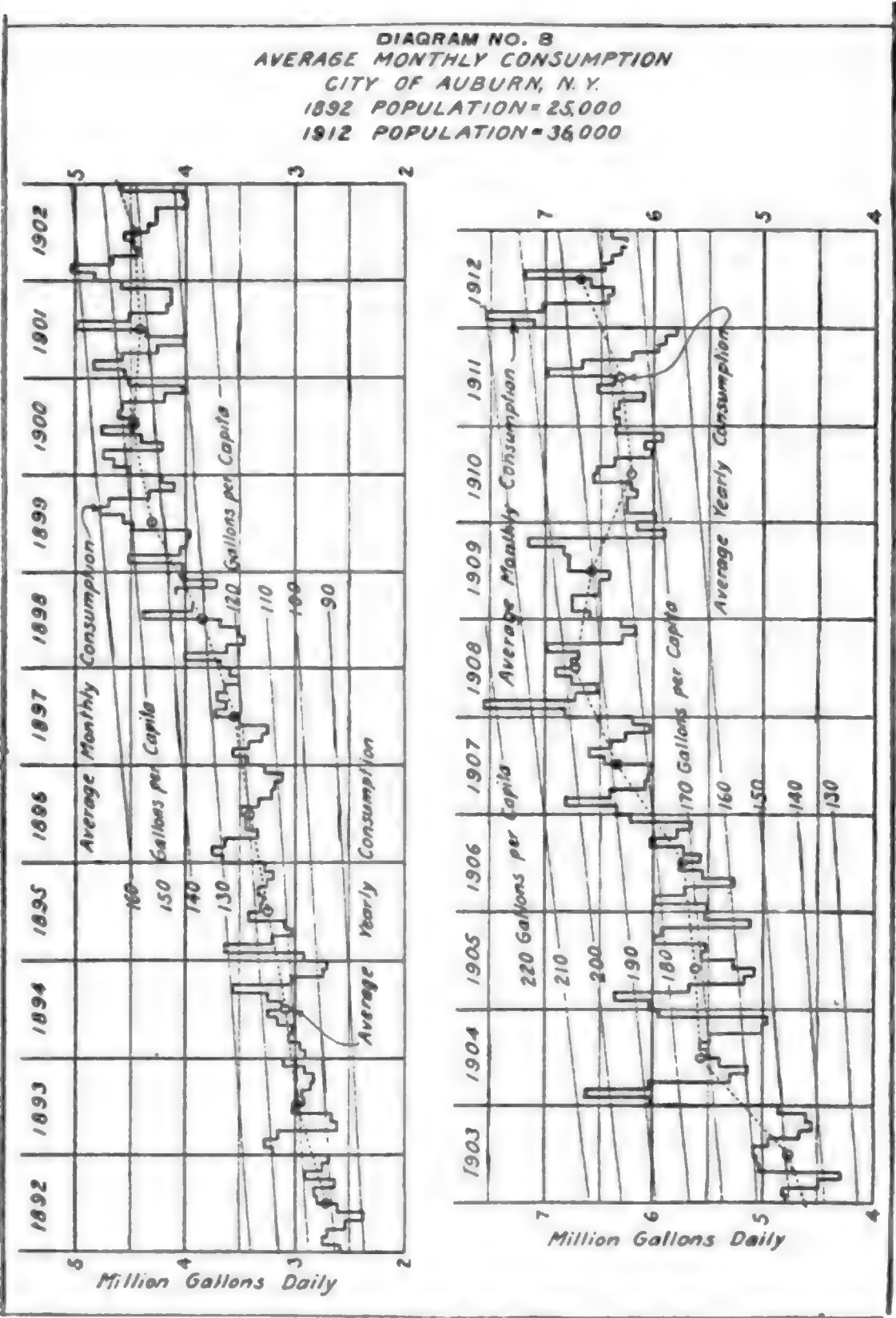


DIAGRAM NO. 9
AVERAGE DAILY CONSUMPTION OF WATER
RAINFALL AND TEMPERATURE OF AIR
CITY OF AUBURN, N.Y.
1912 - POPULATION = 36,000

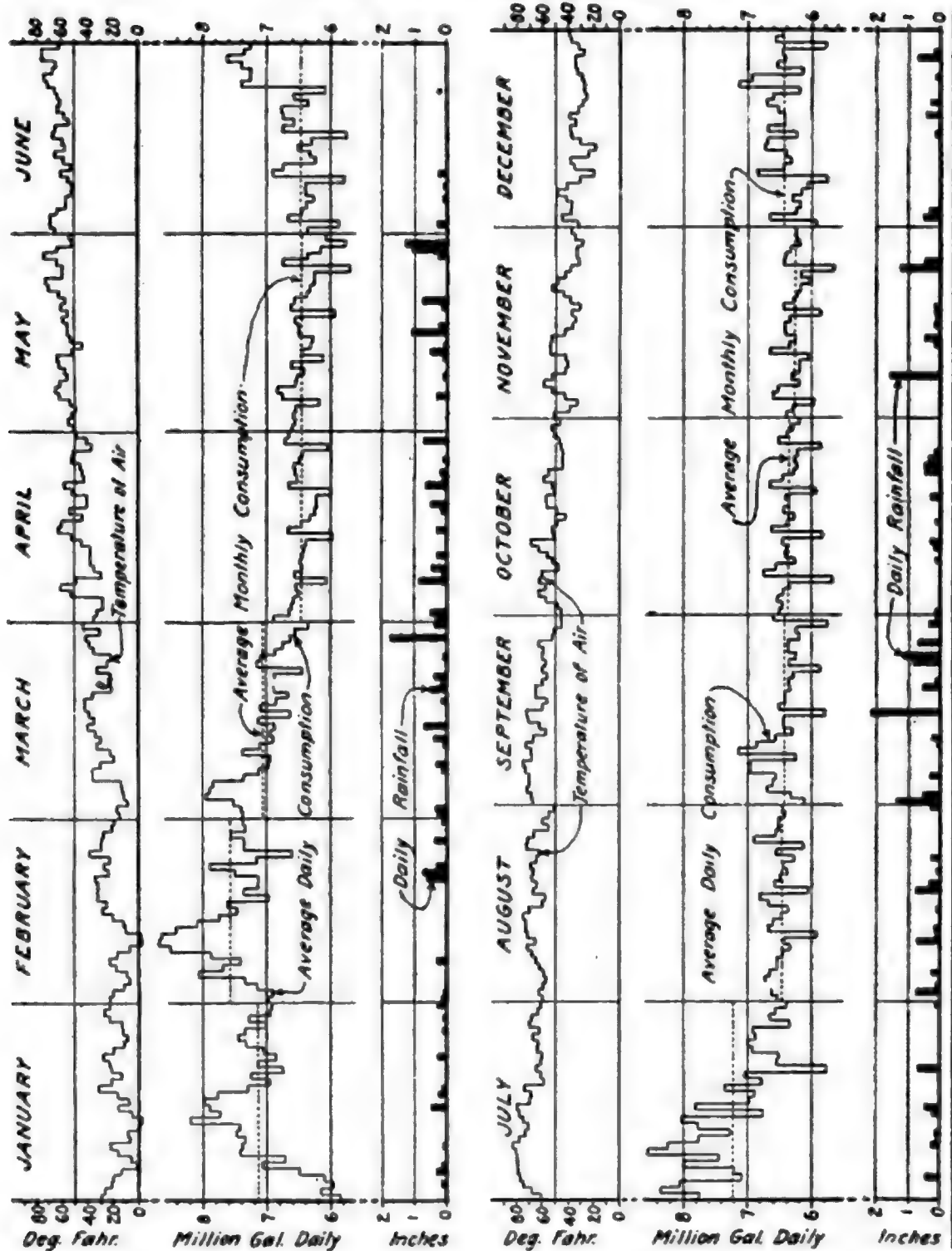


DIAGRAM NO. 10
HOURLY VARIATION IN COLD WEATHER CONSUMPTION
CITY OF AUBURN, N.Y.
1912 POPULATION 36,000.

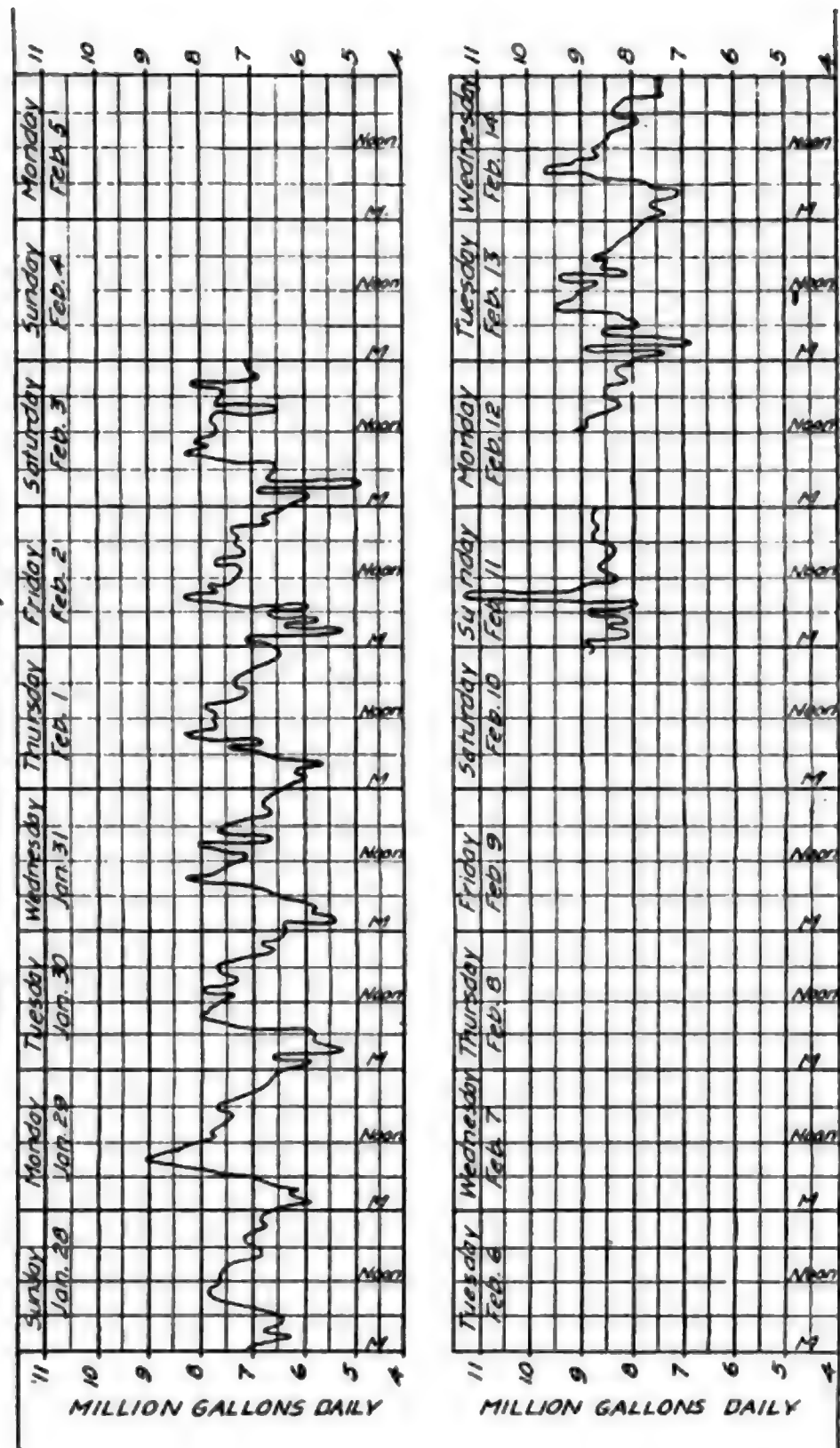
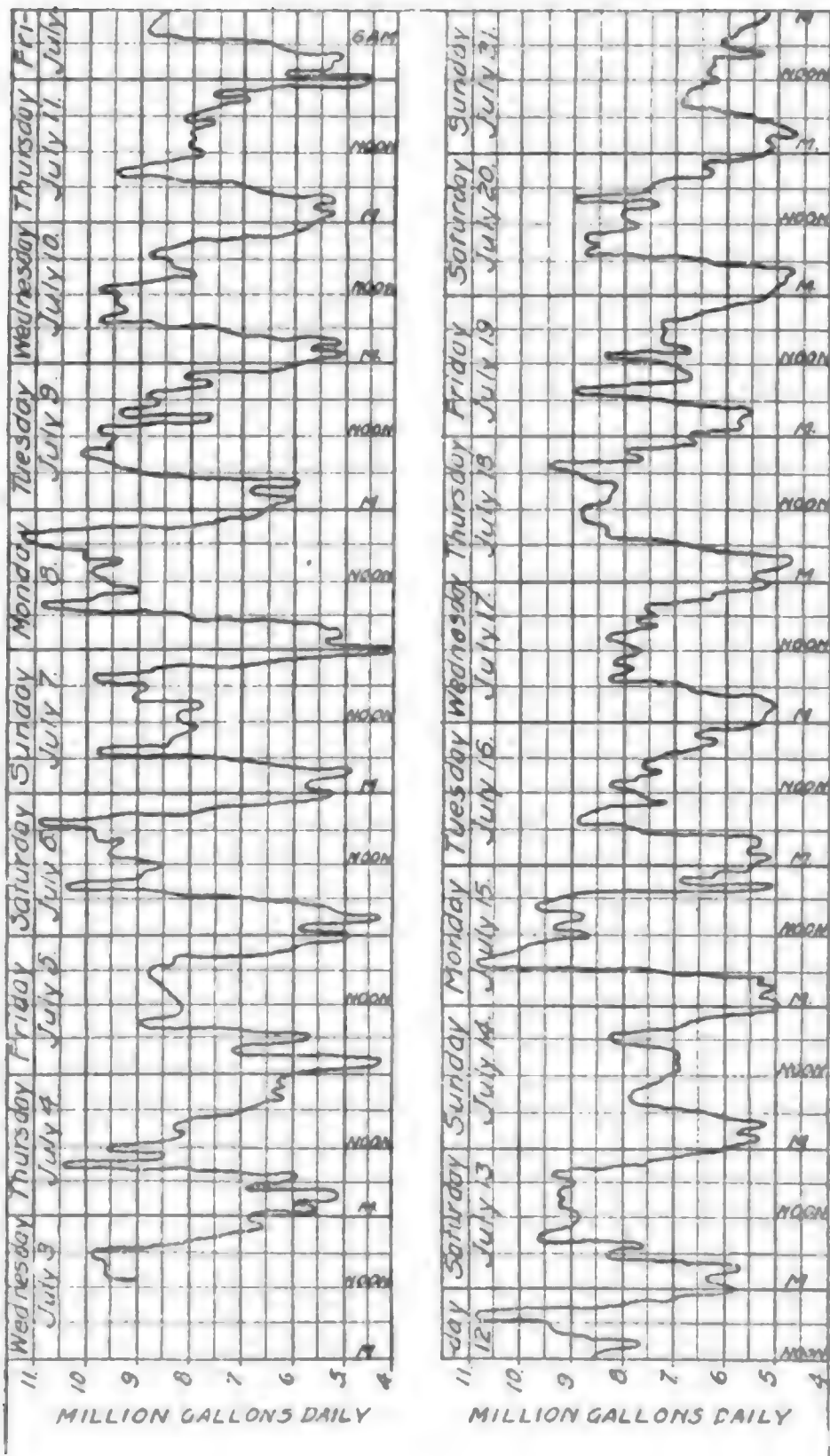


DIAGRAM NO. 11
HOURLY VARIATION IN WARM WEATHER CONSUMPTION
CITY OF AUBURN, N. Y.
1912 POPULATION 36,000.



increase in total and per capita consumption during the period covered by the record. The population during this interval increased from about 25,000 to approximately 36,000 people.

Diagram No. 9 gives the daily fluctuations in consumption for each month of the year 1912, together with the corresponding average daily rainfall and air temperature.

Diagram No. 10 indicates the hourly variations in cold weather consumption from Sunday, January 28, to Saturday, February 3, 1912, inclusive, and from Sunday, February 11 to Wednesday, February 14, 1912, inclusive.

Diagram No. 11 shows the hourly variations in hot weather consumption from Wednesday, July 3, to Sunday, July 21, 1912, inclusive.

These data, all relating to the same community, are interesting and illuminating.

In the twenty-one years covered by the record, the total average daily consumption per capita increased from 100 gallons in 1892 to practically 200 gallons in 1908. The value in 1912 was 188 gallons daily per capita.

A clear relationship is observable on Diagram No. 9 between the average daily consumption and temperatures which are much above or much below the normal. It is also possible to trace in a general way a relationship between the curve of average daily consumption and the daily rainfall as recorded on the same sheet. In July, August, September, for example, there are numerous days on which a heavy precipitation was accompanied or immediately followed by a large drop in the daily consumption.

February was the month of highest consumption in nine out of twenty-one years, July being the highest month during six of the remaining twelve years. The average daily consumption during the highest one month varied from 1.02 to 1.18 times the average daily consumption for the corresponding year. It averaged 1.11 times the latter value. In the year 1912 the day of maximum consumption occurred on February 10, the month of maximum consumption, and amounted to 1.31 times the average daily for the year. On July 8 of the same year the average daily consumption amounted to 1.28 times the average daily for the year.

The hour of greatest hot weather consumption in 1912 occurred about 7 p.m. of July 8, the day of highest hot weather consumption. It amounted to 1.68 times the average annual daily rate.

The hour of greatest recorded cold weather consumption occurred at about 9 a.m., February 11, the morning following the day of highest cold weather consumption. It then amounted to 1.69 times the average annual daily rate, practically the same as the maximum hourly hot weather consumption. In general, higher hourly maxima and lower hourly minima were recorded during the month of July than during the month of February.

For purposes of distribution system design it will not usually be necessary to provide carrying capacity for a quantity greater than the estimated average daily demand during the maximum one week of the period considered, in addition to the fire service requirements. The worst that can happen as a result of failure to design the mains for the occurrence of the maximum fire service requirements coincident with the maximum daily or hourly demand for water for all other purposes, will be a slight reduction in the fire pressures below those which the system is designed to give. Any well designed distribution system is sufficiently flexible to carry overloads for short periods with no other effect than a slight reduction in the maximum fire service pressure.

At all ordinary times, and even during times of moderate sized fires, mains which have been designed to carry the quantities required to satisfy the maximum demands during a conflagration in the maximum week of the maximum year will have ample capacity to deliver the maximum daily and hourly demands without appreciable loss of pressure.

It may also be remarked in this connection that there is a normal tendency to a reduction in the volume of water required for purposes other than fire during the occurrence of an exceptionally large fire, and, finally, it may be said, that the probability of a conflagration occurring coincidentally with the maximum daily or hourly flow in a maximum year is so remote that it would not be commercially expedient to provide for it.

Abnormal Fluctuations in Consumption

In addition to the normal hourly, daily and seasonal fluctuations in the quantity of water required, every water works plant is subject to more or less sudden, violent and abnormal fluctuations in demand. This is particularly true of small installations, though these sudden demands must not be lost sight of even with larger

plants, as they materially affect the size of mains required to give adequate service under all conditions.

Although many kinds of industrial service entail sudden demands for large quantities of water which must be given special study in order that they may be met without crippling the service, the chief cause of these sudden and violent fluctuations is the fire service requirement.

In a plant supplying on the average 1,000,000 gallons per day, which is equivalent to approximately 700 gallons per minute, it may be necessary to supply on short notice eight or ten fire streams delivering 250 gallons per minute each, a total of from 2,000 to 2,500 gallons per minute, or from three to four times the normal delivery. This delivery must be met without undue loss of pressure if the fire service is to be effective, and it is necessary in designing a distribution system to make provision for these sudden and excessive demands.

Fire Service Requirements

A number of rules and formulae have been deduced for estimating the quantity of water necessary to afford proper fire protection in communities of different size. No one of these formulae is of universal application, and, for the most part, they give results considerably in excess of the values which actually obtain generally in the United States.

Table No. 9 gives a few of these formulae.

The National Board of Fire Underwriters does not estimate the number of fire streams required in the congested value districts in cities of different size by formulae, but has determined the number which it considers adequate in a large number of American cities from a special investigation of the conditions in each place. The formula given as that of the underwriters is the equation of a curve representing the average of the published requirements for the cities investigated and reported upon by this Board from 1905 to 1911, classified according to size. See paper "Reasonable Return for Fire Hydrant Service" by Metcalf, Kuichling and Hawley, *Proceedings of the American Water Works Association*, 1911.

That there is no fixed relation between population and the maximum number of fire streams required for adequate fire protection is indicated by a study of the individual points from which this equation was deduced. There is, for example, one instance in which

the Board estimates that 10,000 gallons per minute, equal to forty simultaneous fire streams of 250 gallons per minute each, under a flowing pressure of 75 pounds at the hydrant, is necessary for the proper protection of a city of 52,000 people and another instance in which this amount is deemed adequate for a city of 360,000 people.

TABLE NO. 9

Quantity of water, and number of fire streams required for fire service by various formulae

(1)	John R. Freeman (1892)		Allen Hazen Emil Kuichling (1897)	National Board of Fire Underwriters (1910)
	Maximum	Minimum	(4)	(5)
Formula giving total quantity of water in gallons per minute required for fire protection service in American towns and cities, at 250 gallons per fire stream per minute	$Q = 250Y$	$Q = 25Y$	$Q = 250Y$	$Q = 1020 \sqrt{X} \times (1 - 0.01 \sqrt{X})$
Formula giving total number of fire streams of 250 gallons per minute each, required for fire protection service in American towns and cities	$Y = \frac{X}{5} + 10$	$Y = 1.7 \sqrt{X} + 0.03 X$	$Y = 2.8 \sqrt{X}$	$Y = \frac{Q}{250}$

X = Number of thousands of inhabitants.

Y = Total number of fire streams required.

Q = Total quantity of water required, gallons per minute.

The wealth per capita, character and location of hazards, and other individual characteristics unrelated to the population of a city, are material factors in the determination of what constitutes satisfactory fire protection. Formulae should, therefore, be used with great caution, in the determination of the number of fire streams required, and individual judgment founded upon local inspection should control.

Subdivision of Water Consumption by Districts

The present and future domestic and public consumption of water in each ward may be assumed to be proportional to the present and estimated future ward population. In some instances, the

accuracy of this assumption may be modified by the fact that certain wards may be supplied in part from local sources, or that most of the non-consumers are located in one or a few wards. Also, difference in the character of the population may increase or diminish the per capita consumption in different wards, but with a knowledge of local conditions and with the exercise of proper judgment, the estimates of the ward consumption may be modified accordingly, if such modifications are deemed necessary.

In considering methods for the proper subdivision of the demands in local areas, it must be borne in mind always that there are so many variables in the supply and distribution of water that it is not possible to figure exact quantities. As is the case in the design of sewers, the distribution system must have a certain factor of safety. Also, owing to the flexibility of a distribution system, particularly where it is reinforced by a great number of smaller pipes forming what might be termed a subsidiary distribution system, deviations in the center of supply from those assumed have but small effect on the usefulness of the system. Moreover, the only effect of a more rapid increase in a certain locality than was anticipated will be a slightly reduced pressure or a shortening of the useful life of the system as planned with the concomitant necessity for reinforcements.

PRESSURES

Service Pressures Required

Following the determination of the immediate and probable future demands for water comes the question of the pressure under which this water should be delivered. If there were no draft of water from the mains, the pressure throughout the system would be that ordinarily termed "static pressure," or the pressure resulting from the elevation of the water in a reservoir. A draft of water from the mains, however, immediately sets in motion the mass of water therein contained, causing friction which is proportional to the draft, and which must be overcome. The dynamic or service pressures at various points on the system may be greater or less than the corresponding static pressure. When the supply is from a reservoir, the service pressure at any point on the distribution system will be less than the corresponding static pressure by the amount of the friction loss between the reservoir and the point considered. When water in excess of the immediate requirements is flowing from a

pumping station into a storage or distributing reservoir, the dynamic pressure at all points between the pumping station and the reservoir will be greater than the corresponding static pressure from the reservoir.

When fire service is furnished directly from the mains, service pressures of not less than 70 to 75 pounds at the hydrant under conditions of maximum draft should be maintained in the congested

TABLE NO. 10

Discharge of 1½-inch smooth hose nozzles Hydrant pressure required—Height and distance of jet

INDICATED PRESSURE BY GAUGE ATTACHED AT BASE OF PLAY PIPE AND SET LEVEL WITH END OF NOZZLE		EXTREME HEIGHT OF JET		EXTREME HORIZONTAL DISTANCE REACHED BY JET		GALLONS PER MINUTE DISCHARGED	POUNDS PRESSURE REQUIRED AT HY- DRANT (OR STREAMER) WHILE STREAM IS FLOWING TO MAINTAIN PRESSURE AT BASE OF PLAY PIPE, AS PER FIRST COLUMN, THROUGH VARIOUS LENGTHS OF 2½ INCH ORDINARY BEST QUALITY RUBBER LINED HOSE—INSIDE SMOOTH					
							50 ft. length	100 ft. length	200 ft. length	300 ft. length	400 ft. length	
							(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Feeble streams	lbs.	ft.	ft.	ft.	ft.		lbs.	lbs.	lbs.	lbs.	lbs.	
	5	11		19		84	6	7	9	10	12	
	10	22	18	39	22	119	12	14	17	20	24	
	15	32	27	59	31	146	19	21	26	31	35	
Ordinary fire streams	20 <td>43</td> <td>36</td> <td>80</td> <td>38</td> <td>168</td> <td>25</td> <td>28</td> <td>34</td> <td>41</td> <td>47</td>	43	36	80	38	168	25	28	34	41	47	
	Fair	25	54	44	99	44	188	31	35	43	51	59
		30	64	52	115	50	206	37	42	52	61	71
	Good	35	74	59	130	54	222	43	49	60	71	82
		40	84	65	142	59	238	50	56	69	81	94
	Excellent	45	94	70	152	63	252	56	63	77	92	106
		50	104	75	162	66	266	62	70	86	102	118
	55	113	80	170	69	279	68	77	95	112	130	
Unusually strong streams	60	122	83	178	72	291	74	84	103	122	141	
	65	130	86	185	75	303	81	91	112	132	153	
	70	136	88	191	77	314	87	98	120	143	165	
	75	142	90	197	79	325	93	105	129	153	177	
	80	146	92	203	81	336	99	112	138	163	188	
	85	150	94	209	83	346	106	119	146	173	200	
	90	153	96	214	85	356	112	126	155	183	212	
	95	156	98	219	87	366	118	133	163	194	224	
100	158	99	224	89	376	124	140	172	204	236		

value districts, although 50 to 60 pounds minimum will usually suffice for residential sections. With these pressures, fire streams throwing from 200 to 250 gallons per minute through $1\frac{1}{2}$ inch smooth nozzles attached to 200 feet of $2\frac{1}{2}$ -inch ordinary, best quality, rubber lined hose may be obtained, as will be seen from Table No. 10. The data there presented are taken from the monograph *Fire Stream Tables* published by the Associated Factory Mutual Fire Insurance Companies, and based upon experiments conducted by John R. Freeman in 1888.

Even with service pressures of 70 to 75 pounds in the congested value districts, it may be necessary, in order to insure the proper protection of modern buildings of great height, either to equip and maintain one or two fire engines, the number depending upon the character and size of the district, and of the buildings located therein, or to require that the property owners install and maintain underwriters' pumps to boost the fire pressure on the distribution mains. For all ordinary towns and cities, however, 70 to 75 pounds at the hydrant will give adequate fire service without the necessity for the use of portable fire engines.

Where fire engines are used, a service pressure of 30 pounds minimum on the mains will usually be ample in residential sections, as this pressure will insure the delivery of water to the fourth story of an ordinary building. With this minimum service pressure some of the higher buildings, such as hotels and apartment houses, may be obliged to install local pumping plants to raise the water for distribution in the higher stories, but in view of the expense of maintaining high pressures for ordinary distribution it is but just that this cost should be borne by the parties benefiting, rather than by the general public.

Number of Service Pressure Districts

In considering the question of pressures, the designer should weigh thoroughly the relative economy of creating more than one service pressure district in cities where there are large differences in ground elevation. If these differences are marked, it may be necessary to create two or more entirely distinct service pressure districts in order that the required pressure at high elevations may not produce undesirably high pressures in the lowlying areas. When this is done, the design of the distribution system in each service district may become a problem complete in itself, as, for example,

in the case where each service district is supplied from a separate source, or the systems may be inter-related and inter-dependent, as in a situation where the feeder mains of one service pressure district must be of sufficient size to carry the water consumed in one or more of the others. Take, for example, the case where water for an entire city is delivered to the highest district, and thence through pressure reducing valves to the pipes in the lower districts. Another case would be when the water is pumped through the supply mains of a low pressure district before being repumped to the high service mains. Even when the differences in ground elevation are not excessive, it may be advisable to create more than one service pressure district in the case of pumped supplies, thus reducing the pressure at the pumps, and, therefore, the cost of pumping.

Static pressure

Having decided upon the service pressures required at various critical points of a system, and the number of service pressure districts into which the city will be divided, the next step is to determine the size of mains required to convey the estimated quantities of water at the required pressures from the immediate source to the various points of use. This source may be a pumping station, distributing reservoir, or the point at which a conduit or supply main delivers to the distribution system.

The problem presented may involve fixed pressures at the immediate source, as, for example, where one has to deal with existing pumping plants, distributing reservoirs, or conduit lines, the elevation of or pressure from which is fixed. Under these circumstances, the sizes of the distributing mains must be figured so that the losses in friction between the immediate source and the points of use shall not exceed the difference in pressures at the two points.

The problem presented may be one in which the initial pressures are not fixed, and where the designer may, at his discretion, determine upon the most economical pressures to be carried at the immediate source. He is then at liberty to adjust pressures and pipe sizes in the distribution system so as to increase or diminish the friction losses therethrough in such ways as economic considerations may suggest.

The problem presented is really the determination of the static pressures required to produce most economically the desired serv-

ice pressures, or the determination of the most practical static pressure to be used. The most advantageous static pressure will be that at which the total annual cost of supplying satisfactory service is a minimum.

Below are listed the principal elements in the construction or operation of a water works plant which will increase or decrease with an increase in pressure carried. The effect of these several elements upon the total annual cost of supplying water must be appraised by the designer and carefully weighed and compared under the various static heads considered, preparatory to a final decision.

Elements in the design or operation which will increase with an increase in static pressure—other things being equal.

1. Cost of pipes composing the distribution system, excluding feeder mains.
2. Weight and strength of house service connections and plumbing fixtures.
3. Cost of service pumping engines.
4. Cost of boilers, stacks, and pumping station auxiliaries.
5. Cost of fuel per million gallons pumped.
6. Cost of repairs to mains in distribution system.
7. Cost of repairs to house service connections and plumbing.

8. Cost of water wasted through leaks in distribution system.

9. Cost of water wasted through house service connections and leaky plumbing fixtures.

10. Quantity of water used per consumer.

Elements in the design or operation which will decrease with increase in static pressure—other things being equal.

11. Cost of pipes composing the feeder mains.

12. Diameter of house service connections.

13. Number and capacity of booster plants required to increase pressures in restricted high areas.

Some of the elements listed above appear at first sight to exert an appreciable influence on the cost of the plant. Analysis, however, will show that a number of them may be discarded from serious consideration.

Generally, the experienced engineer will be able to weigh the relative effect upon the cost of the several considerations affecting the selection of the most advantageous static head, without elaborate calculations of the relative economy of several schemes.

In addition to the effect exerted upon the cost by the elements mentioned above, the cost may be affected by external considerations, characteristic of the particular community considered, such as the greater land values of the reservoir sites at low elevations, or

vice versa, topographical considerations which would make the cost of a reservoir at one elevation more costly than one at some other level, or the existence of expensive structures which it would be commercially inexpedient to discard.

Having now discussed generally the various external features affecting the design of a pipe distribution system, we come to the specific consideration of the system itself.

The function of a pipe distribution system is the conveyance of water from the point at which the water is delivered to a community to the point at which it is to be used. This delivery must be accomplished in such a manner that an uninterrupted and adequate supply of water under satisfactory pressure will be available at every point on the system under all conditions of demand. The supply must be sufficient in respect of pressure and volume not only to meet the present and future demands of ordinary domestic and public consumption, but to supply the needs of large industrial consumers and for the extinguishment of fires. It must be able to meet not only the *average* present and future demands of these several classes of consumers, but such of their maxima as are likely to occur simultaneously. The pipes should be of a size sufficient to supply these maxima after proper allowance has been made for deterioration in the carrying capacity of the mains as a result of tuberculation and from other causes.

The delivery of water must be accomplished at a cost as low as is consistent with a wise provision for the future growth of the community to be served. By low cost is meant not necessarily the first cost, but the total annual cost including fixed charges, depreciation, replacements, maintenance and incidental costs chargeable to poor construction, such as losses of water through leakage, etc.

The actual design of a distribution system including a detailed analysis of the effect of various elements herein discussed upon the cost thereof will be left for another paper.

DISCUSSION

MR. JOHN W. ALVORD: Mr. Hill has gone very carefully into a very important matter when he points out the large investment made in our distribution systems and the usually scant attention given to the design, care and enlargement.

It is a matter of common knowledge to those of us who investigate a great many plants that many of them are deficient in distribution capacity, and that this condition is usually caused by the growth of the community, the large investment involved, and the economies demanded by the different administrations of the city government from year to year. These influences cause the distribution system to pass into inefficiency almost insensibly. Without a thorough and general over-hauling at stated intervals, this often results in a public calamity and unquestionably a great deal of good can be done by having a careful study of distribution systems made and plans outlined for enlargement and growth, once in a given number of years, depending on the growth of the city. The speaker would point out, however, that the proper capacity of a distribution system design rests almost wholly on the fire protection requirements. It must be designed for the fire protection and when so designed is usually ample for all other purposes. This fact simplifies greatly the questions which must be studied with reference to it. There is, however, a great deal of data which can be gathered and studied both with reference to the present and the future needs along the lines of fire protection. It would certainly be very profitable if studies of this kind could be more often made.

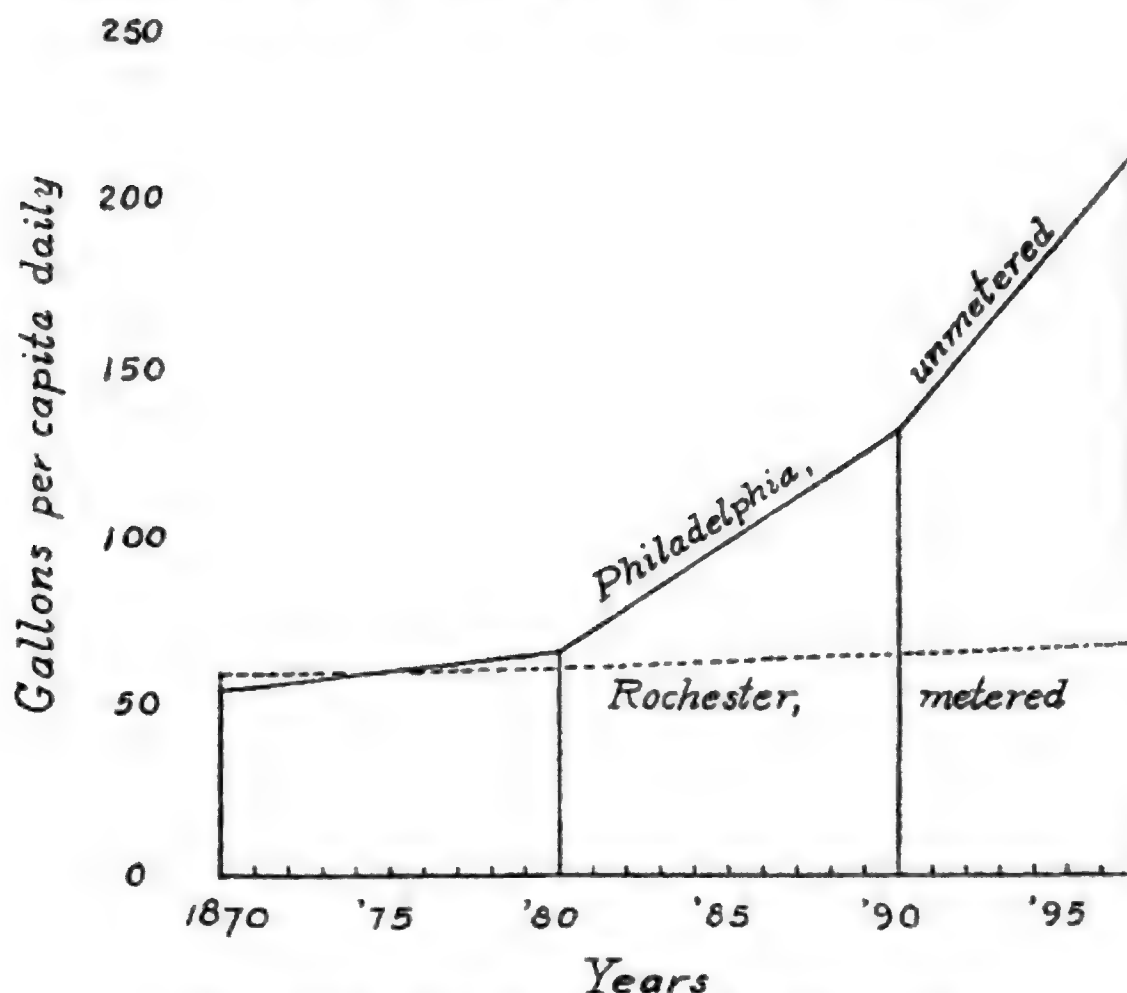
MR. JOHN C. TRAUTWINE, JR.: Mr. Hill has mentioned the case of Rochester, N. Y., where, forty years ago, with less than 2 per cent of the taps metered, the consumption was less than it is today with nearly all the supplies metered; but Mr. Hill, the speaker is sure, would not wish to cite this case as arguing inefficiency of the meter as a waste-restricter.

The object of metering should be to restrict waste, not to discourage legitimate use; and, as the case of Rochester shows, legitimate use properly increases as we advance in civilization and in culture.

Hence, in order to estimate the value of the meter in Rochester, we must compare the present consumption, with nearly all supplies metered, not with the consumption of forty years ago, but with *what the consumption might now be* if meters had not been generally applied.

And, if it be objected that we have no data as to what the Rochester consumption might now be, without meters, the speaker sug-

gests, for comparison, his own unhappy city of Philadelphia. Here, although the city charter leaves such questions to the department of public works, they are really settled, in defiance of the charter, by the ignorant populace and by its representatives in the City Councils; and the water meter is still practically unknown.



INCREASE IN DAILY PER CAPITA WATER CONSUMPTION.
 ROCHESTER, N. Y., METERED.
 PHILADELPHIA, UNMETERED.

Forty years ago, our (unmetered) consumption was about the same as that of then still unmetered Rochester; but, during the forty years, while Rochester, steadily increasing its use of meters, has kept its consumption down to a figure but little greater than that of forty years ago, Philadelphia's consumption, still practically unmetered, has quadrupled.

The nature of the comparison is indicated by the accompanying sketch, drawn roughly to scale.

Mr. Hill mentioned, incidentally, some of the disadvantages under which small communities labor by reason of their smallness and of their consequent lack of means. For instance, while a large city can well afford to engage the services of a commission composed of the highest-paid engineers of the country, the small town must be content with talent of a lower order, if indeed it does not force its problems of extension, etc., upon its already overworked and underpaid superintendent.

Now this consideration, which affects all the relations of the small town, often compelling it to false economies in all directions, emboldens the speaker to venture the prediction that, fifty years from now, all the municipal water supplies of the country will be administered from Washington, or from wherever the national capital may then be, and that, a hundred years from now, all the water supplies of the world will be administered from the world capital. If this sounds chimerical, the speaker asks you to remember that our always progressive Massachusetts friends have already made a notable move in this very direction, in the creation of their Metropolitan Water and Sewerage Board, which administers the supply not only of Boston City, but that of adjacent communities, which, formerly, had their separate supplies.

In Italy also, the national government is constructing a gigantic supply, carrying spring water through the Apennines, at a total cost of some \$30,000,000, for the supply of the arid district of Puglia, on the opposite side of Italy, with its population of about 3,000,000.¹

The usual answer to predictions of centralization is that each community knows its own needs and resources better than could a national bureau at Washington; but this is disproven by the two cases just mentioned, and by the fact above cited that the smaller community cannot afford to employ the highest talent; whereas the predicted centralization will give to every community, large or small, the benefit of a large organization of experts, with resident assistants in each community, and with facilities for gathering and using information as superior to those of the present consulting engineer, as those of the United States Weather Bureau are superior to those of any possible private organization of weather experts.

¹Since writing as above, the writer has received, from the American Society of Civil Engineers, a circular from its special committee "on a National Water Law."

And, even if each community best knew its own problems, it need scarcely be mentioned that it has not the nation's power of physically solving those problems; and it must be borne in mind that, in the next fifty years, we, or our successors, will have attained to a far livelier realization than at present of the fact that the health and wealth of the whole are dependent upon those of each part.

And this consideration leads to the controlling one that, even if each community had the necessary understanding of its own needs, and the means for satisfying those needs, it would be glaringly absurd to suppose that it has the knowledge and power and disposition to adjust the supply of those needs to the needs of its neighbors.

Under the predicted centralization, the present squabbles between neighboring towns, over sources of supply, and the spectacle of a great city supplying its own needs with practical disregard of the needs of other communities within reach of its supply line, will be looked back upon with sorrowing wonder that so imperfect a civilization could so recently have existed.

MR. NICHOLAS S. HILL, JR.: The author would like to say to Mr. Trautwine that the illustration of the increase in per capita consumption notwithstanding the introduction of meters, was not made for the purpose of showing that meters were not productive of economy; but rather to prevent the water works man, in designing his distribution system, from saying that because of the introduction of meters there would be no further increase. If Mr. Trautwine closely followed the paper he would remember that the author said, particularly in the case of Cleveland, that if meters had not been installed the per capita consumption today would have been probably 100 gallons in excess of what it is at the present time; showing that although there was a gradual and continued tendency toward an increase, notwithstanding the introduction of meters, yet the saving due to the introduction of meters was enormous.

The author also wants to say that he thinks that this matter of having insufficient mains to provide for proper expansion of the system from time to time, as the requirements may demand, is one of the wrong financial policies upon which our water works systems are carried forward. If it can be shown that by laying a 10 inch pipe in lieu of a 6 inch today, the gross cost of that plant twenty years hence would be less than by laying the 6 inch main today and laying another 6 inch main ten years hence, it is only fair to

assume that the policy of laying a 10 inch main today is going ultimately to redound to the better financial interests of the plant.

The point that the author wants to make is this, not to let the first cost override all other considerations; a tendency to which the American people are or have been strongly inclined; an inclination which is characteristic of every new nation and every new community, because of financial stress and the difficulty of raising the funds for the first outlay. But we are fast getting into such a financial position that we are enabled to sit down, sharpen our pencils, and consider not first cost alone, which is only one element of the cost. If we could only fully realize that the first cost is only one element of the cost, we could sharpen our pencils and determine what is going to be the lowest average cost, not the first cost only, but also depreciation, interest, maintenance, and replacement, in fact, all the elements that go to make up the total cost and should be included therein.

MR. PAUL HANSEN: May the speaker ask Mr. Hill what method he would employ in the designing of an ordinary cast iron distribution system; that is, how many years in the future he would think it necessary to provide for and how he would go to work to forecast the future proper demands within the period taken?

MR. NICHOLAS S. HILL, JR.: The author tried to take up that question in the paper which he presented to the Association, by showing the relative cost at the end of a period of twenty years, of laying a small main now, and duplicating it at the end of ten years, compared with the cost of laying a larger main now. This is the simplest way that he knows of getting at it. In general, his experience has led him to believe that it is economical to plan at least twenty years ahead; that a water works department or water works company will be in pocket at the end of twenty years, if today they plan for that period rather than to plan simply to take care of immediate needs as they see them today.

MR. J. N. CHESTER: Most of us have visited Washington and probably been taken by professional guides out to that side of the capitol which does not face the city and have been told by the guide how when George Washington and his architect laid out the city they intended that it should be built to the east of the capitol building,

but the real estate dealers and others decreed to the contrary, and it grew in an absolutely opposite direction from what Washington intended, when he laid out the city.

Now while Mr. Hill's paper presents a compilation of a great deal of data, especially as to monthly, daily and hourly consumption, which is valuable for reference, his conclusions in the latter part of the paper, and the theories laid down, it would seem are applicable more to new towns and cities and to new conditions than they are to the conditions that we must meet. The cases in which engineers east of the Mississippi River are now called upon to design entirely new distribution systems are very infrequent; in fact, do not occur in a lifetime with some of us; but the problems against which we are constantly bumping our heads are those of the cities now in existence, and they are being drawn hither and thither by not only the real estate agent but by the location of new factories, public institutions, railroad shops, etc.; all of which create abnormal conditions, and it is not a matter of what can you do theoretically, but what can we do to make the best use of what we have and add to the present installation sufficient to meet the demands that are being created. Butler, Pa., nestled down among the hills, thirteen years ago had an average consumption of not quite 2,000,000 gallons per day. The Standard Car Wheel Company located its plant at that place, and doubled the population of the town in three years. It was not a matter of theory, it was not a matter of taking up old pipes, but we reinforced the old system and also got mains into that part of the town where the growth had been created for this enormous new industry.

It is not a new thing, especially in the district that we have operated in, which is east of the Rocky Mountains, to find cities being drawn on in just that way; the speaker cannot see just how we can apply these formulas of cost and still best meet local conditions. We must meet the conditions that we have.

Another thing to which exception may be taken in Mr. Hill's paper, is the statement that fires seldom occur at times of maximum consumption. The speaker has been responsible for the operation of a number of water works, and can say that fires do often occur at times of maximum draft, and when they do they are very embarrassing, especially when you are not possessed of the capacity to cope with them.

MR. W. S. CRAMER: The speaker was particularly interested in Mr. Hill's reference to the effect of sewerage cities and the increasing population with reference to increasing the per capita consumption. The experience in Lexington, Ky., was that in 1900, with 20 per cent of the city sewerage, and with 96 per cent of our supply metered, the per capita consumption was 40 gallons; in 1912, with 40 per cent of the city sewerage, with an all metered supply, the per capita consumption had risen to 60 gallons per capita.

MR. H. C. HODGKINS: The first statement made by Mr. Hill, if the speaker remembers correctly, was that the distribution system would cost about 60 per cent of the entire cost of the plant. A rule of thumb that the speaker has used in the central west where the works consisted of a standpipe, no expensive reservoir, no filter plant, and in towns ranging from 10,000 to 20,000 population, was that as soon as he knew the tonnage and cost of iron pipe he would multiply the cost by 3 and so arrive at a result that was generally within a few thousands of dollars of the cost of the plant.

An experienced man frequently finds that his plant has become inefficient and too small in capacity; occasionally he may find that it is too large in capacity, when of course he is asked, "Why were you extravagant when you designed and built this plant?" In view of such experiences this paper is particularly *apropos*, and is excellent in its statement of fundamental principles and in the general directions given as to methods of procedure. But after all, these are simply for basing judgment and not an absolute rule; for instance: when the City of Toronto employed an engineer, in about 1906, and paid him what seemed to us in those days a very large fee, \$15,000, he prepared an elaborate table to the effect that in 1940 the City of Toronto would have a population of 450,000. Before one-third of that time had elapsed the population had reached that figure, and it would be a very difficult matter to find anyone in Toronto now who does not believe that in 1940 it will have 1,000,000 population. So that the figures that he made up would under present conditions appear to be poor planning; yet the speaker does not think anyone will undertake to say that he did not use good judgment or that he was not well equipped for the work he had in hand.

The question of your pipe distribution becomes occasionally a very pertinent one; for instance: you find some systems where they pump directly into the mains; and where hydro-electric power is very cheap, and it is a proposition then of pumping with electrically driven turbine pumps directly into such a system. If Mr. Hill wants a real nut to crack, let him proportion such pumps to provide a high maximum load, and also for a minimum load, and see where he would come out.

MR. W. C. HAWLEY: It would seem that with reference to the per capita consumption we must take into consideration the rate at which water is sold. If the quantity rate is high and the minimum rate small, there will be a minimum use of water, whereas much more water will be used, and leakage not watched closely when the minimum rate is such as to allow a liberal quantity of water, or when the quantity rate is low; and these conditions will have to be considered in all cases. It is difficult to do this because of the shifting of rates by our city councils without carefully studying the costs of furnishing the water.

MR. J. M. DIVEN: Mr. Hill speaks of the contours. There are so many things we want to get on our distribution map that contour lines have been found greatly in the way and the speaker has adopted the practice of indicating the elevation of fire hydrants above datum in figures on the maps.

Mr. Hill spoke of the insurance maps getting out of date. These very convenient maps are now being kept up to date by the insurance people. A man comes around once a year to correct them. Slips with all changes are pasted over parts of the maps where changes have occurred.

MR. N. S. HILL, JR.: The author wants to make more clear the point that he wished to make in regard to Mr. Chester's comments on the paper. We all realize that in every community there are changes which cannot be foreseen; some of these changes are sudden, and in many instances they are directly opposite to the preconceived notions or the estimates of the engineer. It is manifestly impossible to prepare for the unexpected; nevertheless that fact should not in any way deter the water works engineer or water works superintendent from making the best possible future estimate

he is able to make with the data in hand. Failure to do so is a mistake. In the long run, if such estimates are made, notwithstanding the sudden conditions which may arise and have to be met from time to time, the total investment in the distribution system at the end of a given period will still be less. The speaker also believes that in many cases, if the local conditions of the community, the trend in adjacent communities, and the trend of development around the particular community, are noted, some conception may be had of the probabilities in the special community under consideration; at least a much more clear conception than would be arrived at by the mere haphazard method of laying pipe here and there, or in some other place, simply to meet such demand as eventuates. In all these estimates, such as a previous speaker brought up in the case of Toronto, all engineers are liable to error, and if we conducted all our business on the plan of refraining from expressing our opinions, and saying that we could not estimate because something unforeseen might happen, we would not go very far along the road toward progressive and intelligent designing.

MR. P. GEAR: The older men in our water works plants will all admit that thirty or forty years ago the water works engineers were not such specialists in water works practice as they are today. Perhaps there is now no class of engineers who are better prepared in their line of work than the water works engineers. When our distribution system was first laid out, the pipe arrangement was suitable enough for it, but with growth and development of our city our distribution system was necessarily expanded. For a number of years our commissioners did not consult any engineer as to the distribution system, but laid such mains as seemed desirable to themselves. However, our distribution system never failed us when it was called on in an emergency, although some of the pipes which were laid were later found to be too small, and had to be taken out. Our city is built on a bank of the river, so that there is no chance for growth except in one direction, and that is toward the reservoir, which helped our distribution system.

THE RAPID FILTER PLANT AT EVANSTON, ILLINOIS

BY LANGDON PEARSE¹

The installation of a filter plant was urged because of the poor condition of the water in Evanston, both from the hygienic and aesthetic standpoints. The intake is only one and one-sixth miles offshore, well within the range of drift for the sewage of Evanston and Wilmette, the greater portion of which is discharged on the lake front. In the winter of 1911-1912 a severe threatened epidemic of typhoid was averted only by the emergency use of chloride of lime.² From time to time breaks in the intake pipe have been found, thereby receiving water nearer inshore.

When the matter was agitated in 1912, Mr. W. W. Jackson and the writer made a report, in August of that year, recommending the construction of a plant of the rapid-filter type. By a popular vote, in the same fall, a bond issue was authorized. Plans and specifications were prepared by Mr. George W. Fuller, of New York City, and the writer, on which bids were received in April. Active construction work commenced in June, 1913, under our direction, with Mr. C. G. Gillespie as the resident engineer, the work being substantially completed in August, 1914. Since that time, Mr. Gillespie has been in charge of the operation of the plant.

Doubtless the water works man will ask why the plant was made of 12,000,000 gallons capacity for an estimated population of about 30,000. The reason for this is the abnormal daily average pumpage in the summer time, the daily average frequently running 12,000,000 gallons per day for a continued period of hot weather, with peak loads for four hours as high as 17,000,000 gallons per day in the afternoon, and on one day after the plant went into service lasting twelve hours. The average daily pumpage by the year has been about 6,000,000 gallons per day for the last ten years (Fig. 1), the effect of increase in population having been taken

¹ Division Engineer, The Sanitary District of Chicago; also, Hydraulic and Sanitary Engineer.

² See *Proc. Ill. Water Supply Assn.*, 1912.

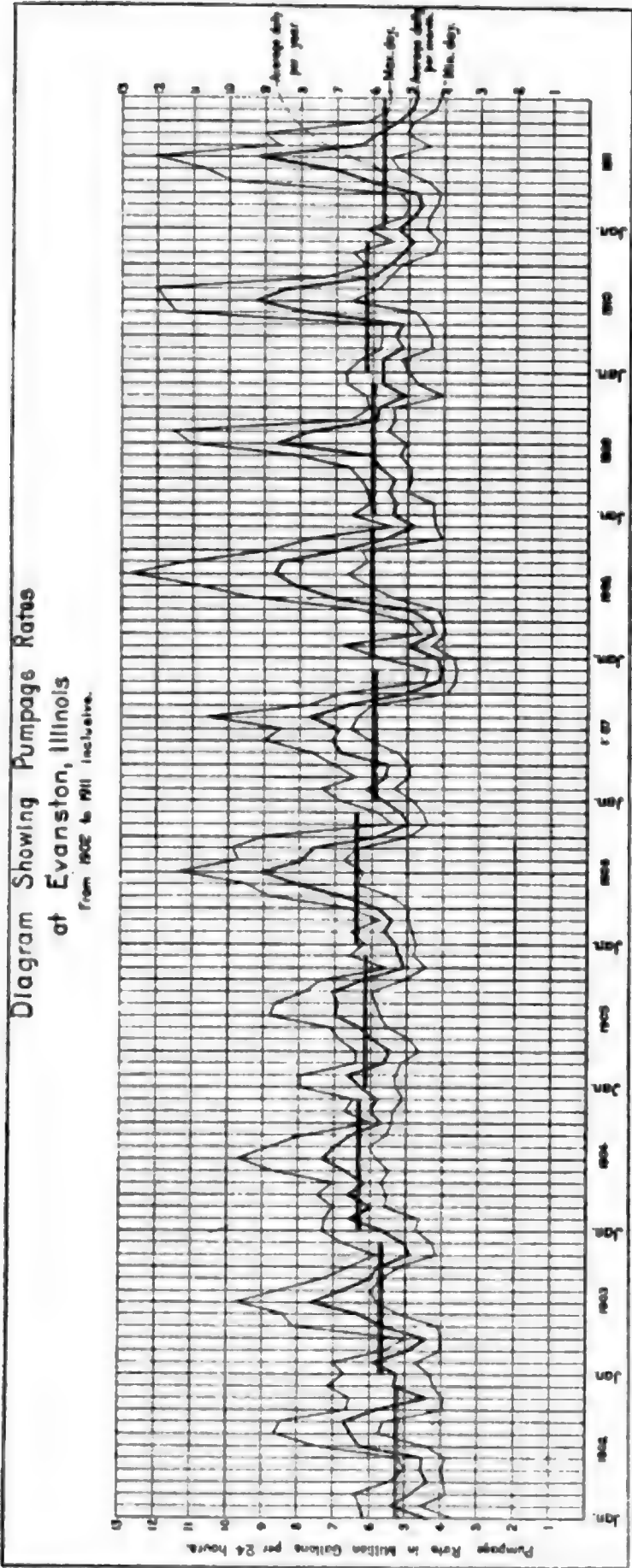


FIG. 1. DIAGRAM SHOWING PUMPAGE RATES AT EVANSTON, ILLINOIS.

care of by inspection of services and leaks. This large use of water is due principally to lawn sprinkling, since the pumpage drops suddenly in summer time on cloudy, and particularly on rainy days (Fig. 2). With the condition in mind of continued daily loads, and the possibility of a healthy growth of population, 12,000,000 gallons capacity seemed a nominal size for this community. This rating is based on the usual rating of 125,000,000 gallons per acre per day.

The filter plant is located on Sheridan Road about one mile north of the center of the city on a site adjoining the Northwestern University and 300 feet from the existing city pumping station. A low-lift pumping station built adjoining the present pumping station is equipped with three centrifugal pumps, one of 10,000,000, one of 8,000,000, and one of 6,000,000 gallons per day capacity, with a total lift varying from 25 to 40 feet. These are geared to steam turbines, with a guaranteed duty in excess of 69,000,000 foot pounds per 1,000 pounds of dry steam for the large units operating condensing with 26 inches vacuum or over. A surface condenser is used, placed directly in the force main, inside the pumping station. A 30 inch cast iron force main conducts the raw water to the entrance to the mixing chamber, a Venturi meter being placed on the line to measure the pumpage.

The mixing chamber (Fig. 3) is about $96\frac{1}{2}$ feet by 14 feet in size, with a depth of 18 feet, having a total capacity of approximately 170,000 gallons, giving a nominal mixing period of twenty minutes. The basin is constructed entirely of reinforced concrete, divided into bays by wooden baffles to maintain velocities of approximately 1 foot per second. The mixing chamber lies between and is part of two coagulating basins (Fig. 4) each about $39\frac{1}{2}$ by $96\frac{1}{2}$ feet in size, and 15 feet deep, having a combined capacity of approximately 830,000 gallons, giving a nominal period of sedimentation of one hour and forty minutes. These are constructed entirely of reinforced concrete with a groined arch roof, each compartment being divided by two concrete baffles into three bays to insure circulation.

The coagulated water flows in a concrete channel across the space left for the extension of the filters to six rapid-filter units, each $23\frac{1}{2}$ by 36 feet inside dimensions, having an aggregate filter surface of 4425 square feet. The filters are grouped on both sides of a pipe gallery, over which is a platform with an operating table for each filter. All the filter tanks, floors and roof are of reinforced

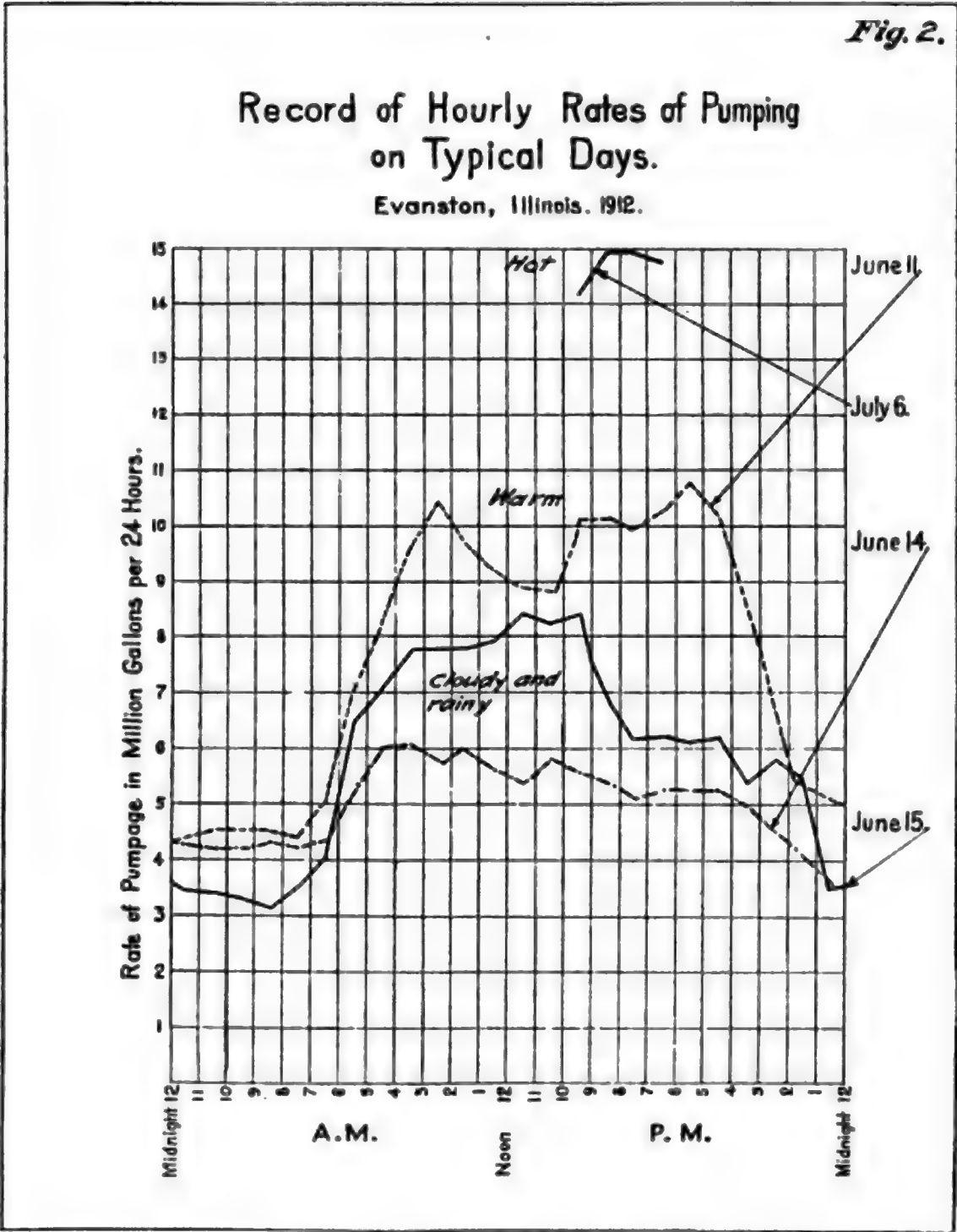


FIG. 2. RECORD OF HOURLY RATES OF PUMPAGE ON TYPICAL DAYS,
EVANSTON, ILLINOIS, 1912.

concrete. Hydraulic valves are used throughout, the controllers for the filters being of a modified Vivian type. The wash water drain, filtered water conduit and raw water conduit are built one over the other, forming a reinforced concrete structure down the center of the pipe gallery. The house covering the operating floor and a part of the filters is of brick with a concrete roof, the inside being lined with a light yellow vitrified brick. The design is so made that the operator can see the entire filter bed at time of washing.

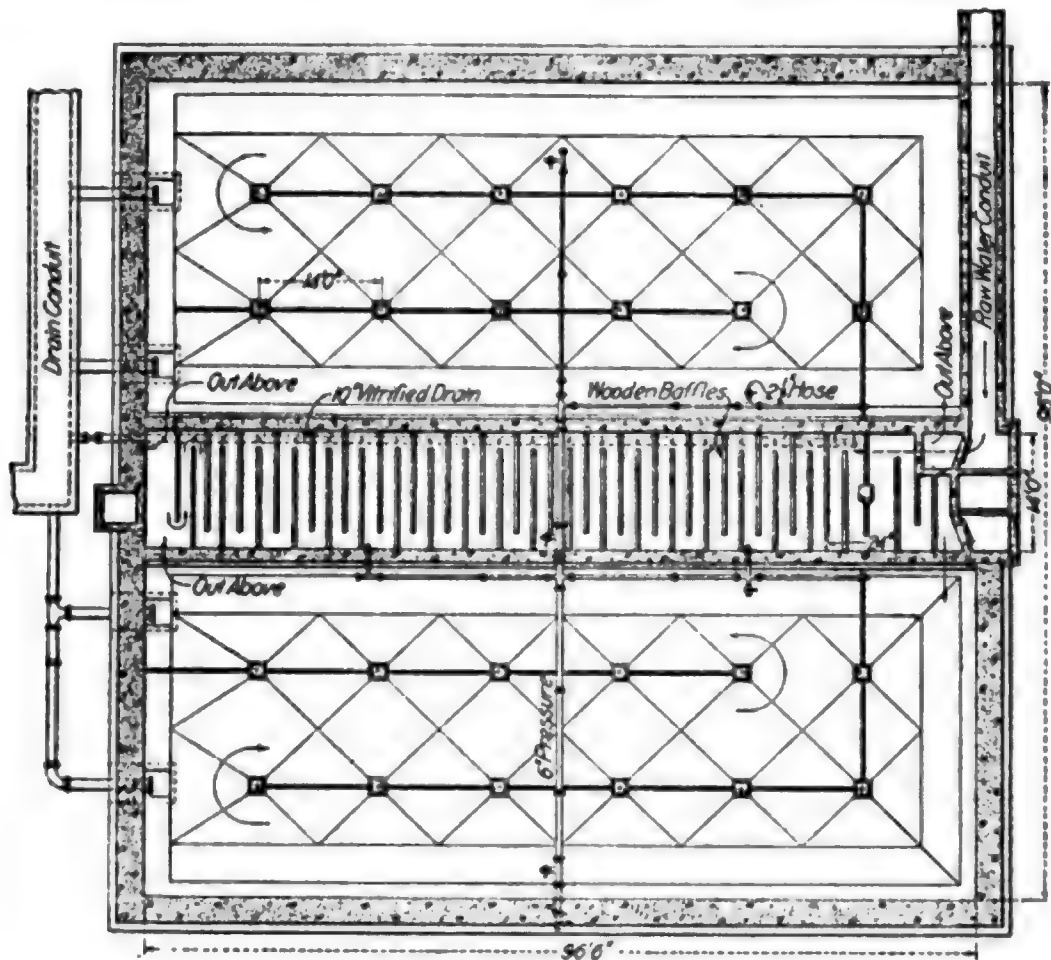


FIG. 3. PLAN OF MIXING CHAMBER AND COAGULATING BASINS, SHOWING BAFFLES.

Both filters and head house are placed above a covered filtered water reservoir, 154 by 161 feet in plan, 12 feet deep, divided into two basins having a total capacity of approximately 2,000,000 gallons. This basin has a groined arch roof, reinforced where necessary to carry the weight of the head house and filters. The standard spacing for the arches is 12 feet 6 inches on centers, with a rise of

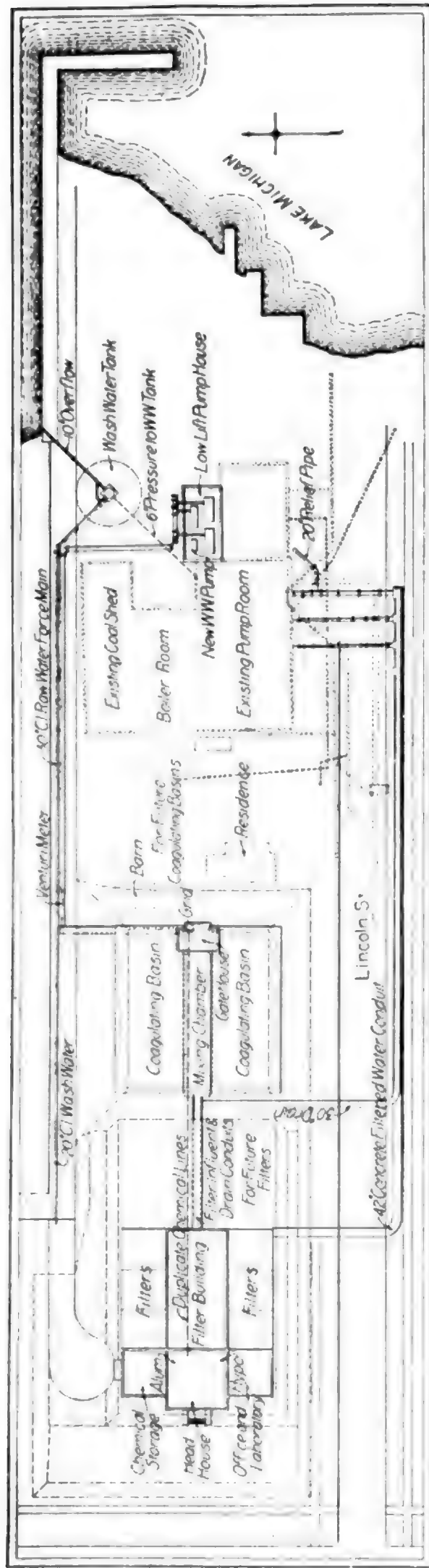


FIG. 4. RELATION OF TANKS, FILTERS AND MECHANICAL EQUIPMENT OF EVANSTON FILTER PLANT

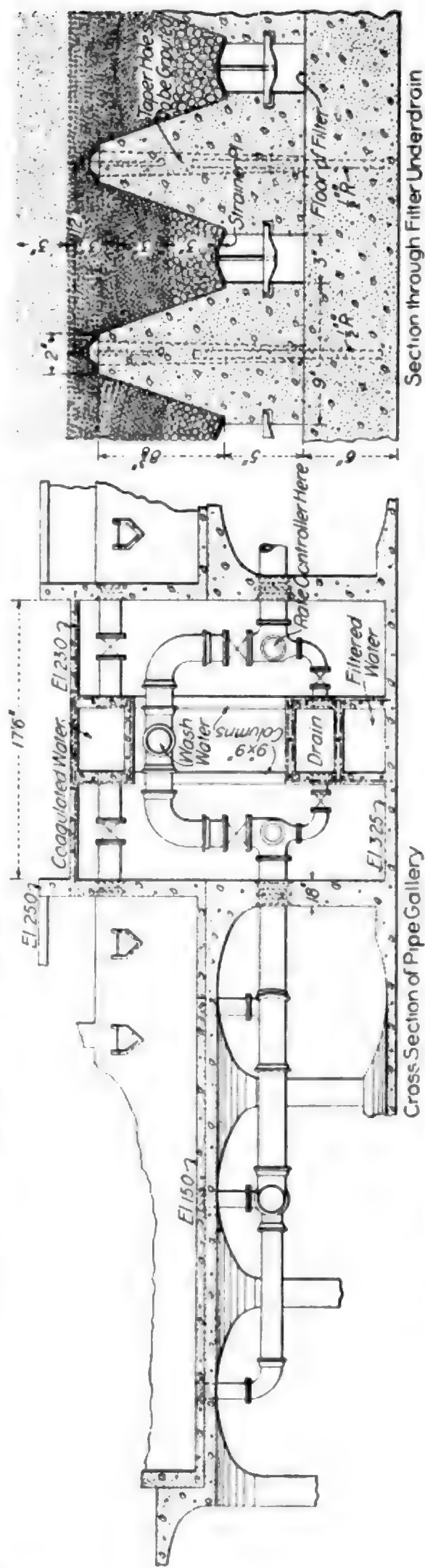


FIG. 5. CROSS SECTION OF RESERVOIR, PIPE GALLERY AND UNDERDRAINS, EVANSTON FILTER PLANT

2 feet 9 inches and a thickness of 6 inches at the crown. The foundation is of firm clay so that the thickness of the floor arches is only 6 inches at the thinnest point.

The two story head house at the head of the filter gallery has two wings, one story each, built of reinforced concrete and brick with prepared roofing. The dimensions of the head house are approximately 28 by 91 feet, and of the filter wing 75 by 36 feet. In the head house are placed the tanks and apparatus for the proportioning and application of the coagulating and sterilizing chemicals, the recording gages, laboratory office, and chemical storage. The second floor of the head house is served by a hydraulic elevator.

The design of the rapid filter units includes an under drain system with perforated brass plates, set at the bottom of valleys in the fashion of the Minneapolis, Grand Rapids, and other plants (Fig. 5). A novel feature, however, is the omission of the wire screen and the use of 12 inches of graded gravel, on top of which the sand is placed. The wash is a high-rate water wash, supplied by a gravity feed from a steel tower tank of 100,000 gallons capacity erected behind the present pumping station on the lake front. It is fed by a bleeder from the present high service mains. Fluctuations in the pressure due to the drop of level in the wash water tank are taken care of by a controller to be placed in the line at the entrance to the filter gallery (Fig. 5).

The work was carried on under a general contract. Owing to the situation, it was impossible to bring material in except by teams, a haul of approximately one mile from the nearest railroad switch being required. Owing to lack of storage room the contractor developed a plant for the elevating and storage of the gravel and sand in bins to minimize the handling by hand. The teams dumped into a hopper from which a belt conveyor delivered the material to the sand or gravel bins. Storage sheds for cement were built alongside the bins. A concrete mixer discharged into two-wheeled buggies on an elevator for raising or lowering the cars of concrete to the appropriate level for placing. One inch yellow pine flooring was used for form work wherever possible, with 2 by 4 inch studs spaced about 16 inches on centers tied with very heavy wire.

The inverted groined-arch column bases were formed up continuously in rows by the use of a "spider," a metal frame consisting of 1-inch angles making a square, from each corner of which malleable castings of the shape of the groin converged to the base











this contained considerable fine material. After removing about 25 per cent by continued washing the effective size was about 0.43 mm., with a uniformity coefficient around 1.44. With a small proportion of Cape May sand added the effective size was increased to 0.47.

In the application of the solutions, through long lines at distant points, the novel feature is the use of lead solution lines, fed by an ejector. This introduces into the lines sufficient water to keep a high velocity. Such lines should be kept straight as far as possible. Incrustation occurred early with both "hypo" and "alum" lines. Rodding of the lines so far has kept them clear. A riser, 6 inches high, inside the solution tanks on the outlet pipe, helps also. The grids for application of coagulant and chloride of lime were early removed, for cleaning, and have not been replaced. In the mixing basin thorough mixing ensues.

One of the most interesting points was the strainer system. Prior to the construction, the existing underdrains of this type were studied, their history developed and provision made for the use of soft brass strainer plates of increased thickness, as well as for increasing the net area of the holes, and placing brass baffle plates over the pipes through the filter bottom. Some of the data collected is summarized in Tables 1 and 2. The original Minneapolis plate was a so called Tobin bronze and showed a very low ductility. Judging from previous strainer construction the details planned for Evanston were entirely safe and reasonable.

After the beds were put in operation, a number of the $\frac{1}{4}$ -inch bolts broke, chiefly because of imperfections at the head, practically none breaking at the root of the thread. In view of the seriousness of breaks caused by flaws in the metal, the $\frac{1}{4}$ -inch bolts were replaced with $\frac{3}{8}$ -inch diameter Parsons bronze bolts, with heavier yokes. The tests of the bolts are given in Table 3. These show a more ductile metal in the smaller bolts. The work was rebuilt, every care being taken to insure true work to avoid secondary or eccentric stresses. The wash water valves were also adjusted to prevent water hammer by quick opening. At no time has a pressure on the plates been observed over 5 pounds per square inch. Yet a number of $\frac{3}{8}$ -inch bolts have broken, some at the root of the thread, some by irregular jagged breaks, practically all showing a non-uniform crystalline fracture, a large portion being large crystals. Bolts actually broken in test showed a very uniform fine-

grained texture. Bending tests showed that some bolts could be bent double, while others snapped before 90 degrees was turned. In no case is there anything to indicate the metal has been overstrained, as the cross-section is practically unchanged. Hence the only conclusion is that the Parson bronze metal bolts are very variable in physical properties, proving frequently defective without warning. Monel metal bolts are now being used to replace breaks.

Subsequent investigation showed that considerable difficulty had been experienced on general water supply work by the Board of

TABLE 1

Physical and chemical tests of strainer plates from Louisville, Minneapolis and Cincinnati

Physical Tests

FILTER PLANT	LOUISVILLE	MINNEAPOLIS	CINCINNATI
Birmingham wire gage.....	14	16	15
Dimensions, in.....	0.084 x 0.737	0.066 x 0.75	0.079 x 0.514
Area, sq. in.....	0.062	0.046	0.040
Reduction of area, per cent..	45.2	10.8	52.5
Elastic limit, lbs. per sq. in..	54850	47800	40650
Ult. strength, lbs. per sq. in.	60100	55450	56250
Elongation in 2 in., per cent.	27.5	10	35.5
Fracture.....	Silky	Broke at perforation	Silky

Chemical analysis in per cent

Copper.....	65.48	60.81	66.96
Tin.....		0.77	
Lead.....	0.21	Trace	0.14
Iron.....	0.08	0.05	0.26
Zinc.....	34.23	38.37	32.64

Water Supply of New York City, and that bolts even as large as 2 inch diameter had broken under no strain (See Brass in *Engineering Construction* by A. D. Flinn, Municipal Engineers, City of New York, Feb. 25, 1914). This points to the need of the utmost care in selecting non-corrosive alloys of high strength, even from careful manufacturers, and the present indications are that such metal should be used with great caution.

The operating results obtained at Evanston are of interest as this is the first large modern plant on Lake Michigan. One of the first

TABLE 2
Data on Strainer Plates

FILTER PLANT	STRAINER PLATES									
	Rate of Wash, Vertical Rise, Inches per Min.		Holes		Gage, B.W.G.	Thickness, inches	Bolts		Channel width, inches	Opening holes, per cent of filter area
	Rate of Wash, Vertical Rise, Inches per Min.	Space on centers, inches	Diam., in.	No. per ft.			Spacing, c/c	Diam., in.		
Cincinnati.....	24	12	$\frac{3}{8}$	64	15	0.072	12 ¹	$\frac{1}{4}$	2 $\frac{1}{2}$	0.3
Louisville.....	24	11 $\frac{1}{2}$	$\frac{3}{8}$	54	14	0.083		$\frac{1}{4}$	2 $\frac{1}{2}$	0.277
Niles.....	24		$\frac{3}{8}$	48	12	0.109				0.23
Grand Rapids.....	24	12	$\frac{1}{2}$	72	16	0.065	12	$\frac{1}{4}$	3 to 3 $\frac{1}{2}$	0.15
Minneapolis.....										
Old.....	24	12	$\frac{1}{2}$	72	16	0.065	12	$\frac{5}{16}$	3 to 3 $\frac{1}{2}$	0.15
New.....			$\frac{3}{8}$	48	14	0.083	4 ²			0.23
Evanston.....	20	12	$\frac{3}{8}$	72	14	0.084	13 ³	$\frac{1}{4}$	3	0.34
Columbus.....	15	8 $\frac{1}{2}$	$\frac{1}{4}$	45 ⁴		$\frac{1}{16}$		$\frac{3}{16}$		0.18

¹ Per plate, 8 $\frac{3}{4}$ in. centers both ways.

² Uses 12 in. spacing of $\frac{1}{4}$ in. U bolts and 8 $\frac{1}{2}$ in. spacing of $\frac{1}{2}$ in. hook bolts.

³ Changed to $\frac{1}{2}$ in. bolts, 13 in., center to center.

⁴ U bolts and yokes.

NOTE. Coefficient of discharge for orifice, "c," was selected at 0.74 from actual tests on similar orifices.

developments was exceedingly short filter runs, the loss of head building up to 10 feet in three hours, frequently in thirty minutes. Investigation showed that this was apparently caused by large amounts of diatoms present, chiefly *Asterionella* (400 to 2000 standard units per cc.). The interlacing arms of this organism made almost a water-tight mat on the surface of the filter. In order to keep the wash water within reasonable bounds, whenever the loss of head ran up to 8 feet or over, the bed was shaken up, by turning on the wash water and as quickly turning off. After two or three shakes, the bed had to be washed, but at periods usually three hours or more. With the diminution of the diatoms to less than 400 standard units per cc. in November, the runs lengthened to eight to sixteen hours.

With the low turbidity and low bacterial counts in the raw water, the removal of bacteria by the filters alone is not complete, 2 to 4

TABLE 3
Tests of strainer bolts

DIAMETER OF BOLT IN.	MAXIMUM STRENGTH		REMARKS
	Actual lb.	Lb. per sq. in.	
0.25	1075	40180	
0.375	5840	86190	
0.375	5140	75720	
0.373	5960	87650	Snapped. Brittle.
0.373	6190	91030	

NOTE. All broke at root of thread. All $\frac{3}{4}$ inch bolts Parsons bronze.

pounds of chloride of lime being used per million gallons as a finishing agent. The turbidity is entirely removed. With varying turbidities, and wide range of flow, the conditions to be met frequently tax the flexibility of the coagulating basins. A secondary application of coagulant just before the water is applied to the filter is of great service, giving a large heavy floc.

Contrary to expectations, the coagulant flocculates very readily, giving large heavy flocs with amounts of 0.6 gram per gallon and upward. In the preliminary laboratory tests of the original report, considerable difficulty was experienced in getting a good floc with low turbidities.

Running at a slight overload, the bacterial removal was over 90 per cent at times with less than 1000 bacteria per cc. on agar at 20 degrees C. in the raw water. With the lowering of the diatoms and the decrease in filter rate to a usual rating, the bacterial removal has increased. Generally 3 pounds of chloride of lime per million gallons, applied to the filtered water, proves effective as a finishing agent, removing all gas formers. One pound is too little.

Under winter conditions the wash water is averaging 3.2 to 4.3 per cent, with filter runs from four to sixteen hours long, the turbidity ranging from 7 to 50 p.p.m. In December, 1914, the results were as follows:

	AVERAGE	MAX.	MIN.
Turbidity raw water.....	20	40	7
Applied.....	15	40	4
Coagulant, gr. per gal.....	0.76	0.85	0.61
Chloride of lime, lb. per mil. gal.....	3.5	5.5	0.9
Per cent wash water.....	4.3	5.9	2.8
Length of run, hours.....	7.3	12.2	4.5
Bacteria per cc. (on agar 20 deg., 4 days).....			
Raw water.....	664	2000	120
Settled water.....	464	1400	90
Filters.....	87	600	0
Plant.....	23	60	0

The treatment of the water at Evanston has largely eliminated typhoid. However, not enough time has elapsed to show the effect of filtration, but the results produced by the use of the "hypo" applied since January 1, 1912, are of interest. For this table the author is indebted to Prof. W. Lee Lewis, city chemist.

TABLE 4
Typhoid fever death rates per 10,000

YEAR	CHICAGO	EVANSTON
1907	17.5	21
1908	15	32
1909	12.5	28
1910	13	24
1911	10.8	28
1912	7.6	14.3
1913	10.6	13.3
1914	7.6	6.6

For convenience in keeping the operating records, several forms were devised, combining the good points of typical forms from many plants. These forms are given herewith. Forms 1 and 2 are for the filter attendant to fill in. Form 3 is filled in each day by the chemist or engineer in charge of the plant, giving a handy and complete summary at the end of each month.

DAILY FILTER RECORD EVANSTON ILL., FILTRATION PLANT DATE

RECORD OF FILTER RUNS AND WASHES

FILTER NO. 1		FILTER NO. 2		HOURLY LOSS OF HEAD											
RUN NO.		RUN NO.		1	2	3	4	5	6	7	8	9	10	11	12
RUN BEGAN		RUN BEGAN													
L. M. AT START		L. M. AT START													
L. M. AT END		L. M. AT END													
RUN ENDED		RUN ENDED													
WASH		WASH													
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CHEMICAL AND GENERAL RECORD—EVANSTON, ILL., FILTRATION PLANT. Date _____

HOUR	RATE - M. G. D.		ALUM DOSE					HYPO DOSE					REMARKS			
	MASTER CONTROL		TOTAL WATER GAL. D	VENT. UM. WATER	MIN. UTE	GR. PICE NO	HEAD FT	THOUSANDS GAL. 24 HRS	GR. GAL.	MIN. UTE	GR. PICE NO	HEAD FT	THOUSANDS GAL. 24 HRS	LOSS M. G	M. G. TREATED _____	
	MIN	READ														
601															V. M.	
11A																
21																
31																
41																
51																
61																
71																
81																
91																
101																
111																
M																
11P																
21																
31																
41																
51																
61																
71																
81																
91																
101																
111																
601																V. M.

SOLUTION TANK RECORD

TANK NO.	1	2	3	A	B	C	
DEPTH AT MDT							
CHARGING START							
" FINISH							
DEPTH-START							
" FINISH							
" FILLED							
LOSS BY CHEMICAL							
LOSS PER FT. IN TANK							
DEPTH AT MDT							
PUT IN SERVICE							
DEPTH AFTER REPAIR FILLING FEET - DRAIN - TANK NO.							

FORM 2. DAILY CHEMICAL AND GENERAL RECORD

REPORT OF COMMITTEE ON WATER CONSUMPTION AMERICAN WATER WORKS ASSOCIATION, 1913-1915

In presenting its report of results obtained to date, your Water Consumption Committee believes that it has made a beginning toward the segregation of water uses in American cities.

Our object has been to improve on the old misleading standard "Total Per Capita use"—total consumption divided by population. Conditions in different municipalities vary so greatly as to render "Total Per Capita" useless for purposes of comparison and in beginning our labors two years ago we sought to divide water consumption into two main classes—*Domestic* and *Non-Domestic*. The latter divided into three sub-classes where possible. Thus we have:

Domestic use: Or that wholly for residential or domestic purposes.

Non-Domestic use: Industrial, or railroads, factories, etc.

Commercial: Or stores, saloons, stables, boarding houses, etc., including double houses.

Public: Or fire protection, street sprinkling, sewer flushing, public buildings, schools, fountains, etc.

The responses received to our circular inquiry were both gratifying and disappointing, gratifying in the large number of returns and disappointing because many cities were unable to classify their meter readings even into the two simple divisions of Domestic and Non-Domestic use. However, we believe we are able to present to the Association a body of fairly accurate data from which valuable conclusions may be drawn, and it is our hope that this beginning will encourage all water works officials to keep their records so that segregated statistics of water consumption may be obtained.

We would recommend that the work begun by this committee be repeated from time to time until more complete records are available to our members on which to base reliable conclusions regarding the legitimate requirements of each class of water users. Concerning these various classes the following observations may be in order.

Industrial use: No community is a criterion for another in this class of use and therefore it is indispensable that data relating to industrial use should be separated from the total.

Commercial use: It will be found that this class of consumption does not vary per capita as greatly as industrial use.

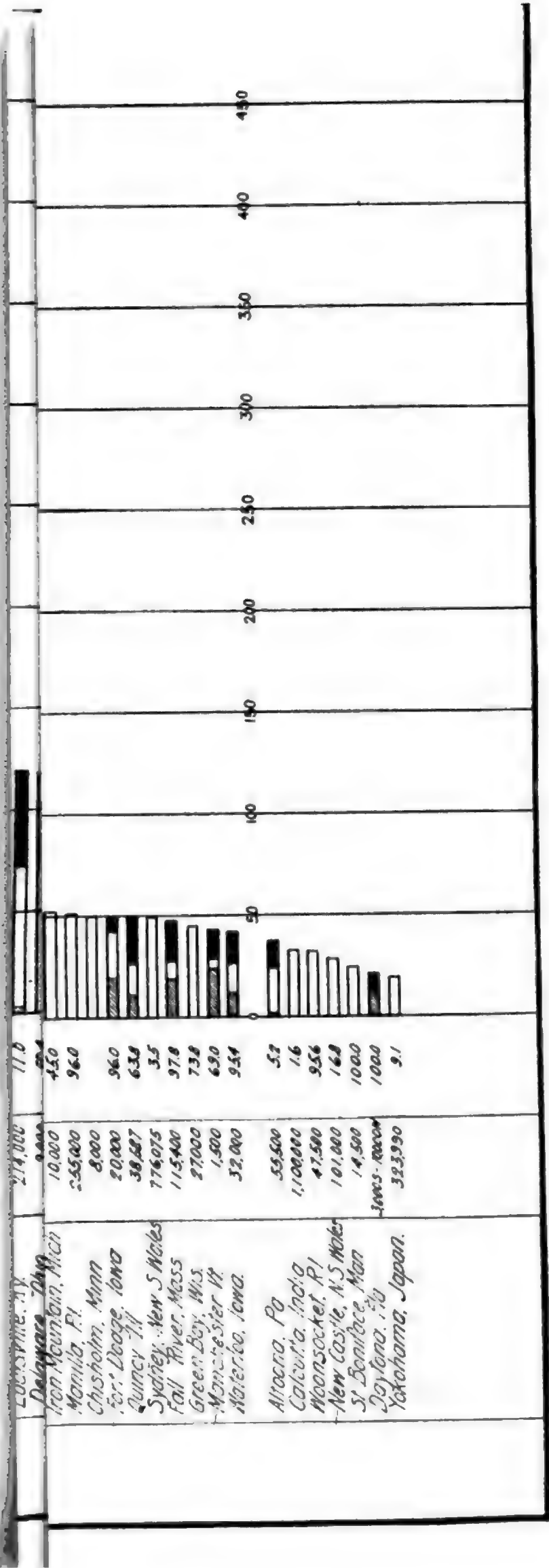
Public use: Here the consumption will vary according as the water is paid for or is free in consideration of franchise rights, etc. We should coöperate with public service commissions in urging water companies and departments to adopt meter measurement and fair charges for all water used for public purposes.

Domestic use: This we have attempted to separate as fully as possible. Our results seem to indicate that the old standard of 100 gallons per capita or even the 50 gallons which has been much used by engineers of late, can now be replaced in most communities by an allowance of 25 gallons per capita daily for domestic use, and that half of this amount is a possibility where meters are in general use. But here tabulated statistics must not be applied without judgment for obviously it is unjust to compare a mill town in Western Pennsylvania having no lawns, few sewers and where poverty or economy reigns; with a suburb of New York or Chicago, having wide lawns, thorough sewerage, and the elaborate plumbing of prosperous homes.

We have attempted to classify double houses, flats, etc., as commercial use in order that our reported domestic per capita—based upon five persons per tap, see column 33 of our table—might be more accurate. Column 32 is however the more reliable index of domestic use.

The gist of our investigation is presented in the form of a diagram in which the cities are arranged in order of their total per capita use, the largest being at the top. Shaded areas show the domestic and non-domestic use, while the space between these areas represents the supply "unaccounted for." When we confine ourselves to those cities having 95 per cent or more of their taps metered, this diagram brings out the "unaccounted for" loss which we know exists in every water works system. It is apparent that this loss varies from 10 per cent to more than 60 per cent of the water delivered to the mains, and here lies an important field for economy and the elimination of underground waste.

This graphical presentation should be of use in various ways; as for example, in rate making cases under public service control, for it is too frequently presumed that all the water pumped is delivered to the consumers, and naturally, rates based on this assumption, sooner or later are found to be confiscatory.



THE
NORTHWEST

In conclusion, we would call attention to the fact which seems to be brought out by our diagram, that the per capita water consumption of a city does not depend upon its size, nor does it seem to depend entirely upon the percentage of taps metered. The largely metered cities, as a rule, are found well down in our diagram; but there are notable exceptions of cities maintaining low per capita rates, although only partially metered.

Respectfully submitted,

JOHN N. CHESTER,
ALEXANDER POTTER,
H. J. MONTOLIEU,
W. S. CRAMER,
E. E. DAVIS,
EDWARD S. COLE,
Chairman.

REPORT OF WATER

Col. 32 = Col. 9 - Col. 21
Col. 8Col. 33 = Col. 19
5

Note:

Col. 32 is correct only when Non Domestic Consumption is fully metered.

Col. 33 is correct assuming 5 persons per meter.

Note:

(a)—Metered houses, with two families or more, are classed as commercial.

* Includes commercial.

CITY	MUNICIPAL OR PRIVATE	PUMPED OR GRAVITY	AREA SQ. MI.	MILES OF MAINS	RANGE OF PRESSURES	RANGE OF ELEVATIONS	POPULATION	GALLONS DAILY CON- SUMPTION
1	2	3	4	5	6	7	8	9
Akron, Ohio.....	M	P	12.0	139.0	25-135	.....	75,000	9,180,000
Albany, N. Y.....	M	P	15.7	151.2	15-90	20-280	102,344	22,486,000
Altoona, Pa.....	M	G	4.0	89.3	25-98	1181-1375	55,500	2,000,000
Appleton, Wis.....	M	P	6.5	45.0	30-65	0-70	17,000	2,380,000
Ashland, Wis.....	P	P	3.0	30.7	20-125	0-100	12,000	1,275,000
Auburn, N. Y.*.....	M	P	4.005	67.8	25-115	.....	36,363	6,550,000
Augusta, Me.....	M	P & G	3.2	45.18	15-130	0-350	11,532	1,895,315
Allentown, Pa.....	M	P	4.9	80.0	30-100	230-420	55,700	7,900,000
Baltimore, Md.....	M	P & G	30.7	789.0	40-110	0-460	395,000	75,200,000
Beloit, Wis.....	P	.....	4.0	28.3	50-90	10-30	18,000	.....
Biddeford and Saco, Me.....	P	P	32.0	67.05	22-83	0-149	28,000 W. 40,000 S.	1,736,000
Brookville, Ont.....	M	P	2.0	20.37	35-75	10-140	9,500	2,480,000
Brunswick, Me.....	M	P	2.0	16.0	50-100	25-100	6,000	458,000
Buffalo, N. Y.....	M	P	30.0	572.0	20-60	5-120	450,000	139,000,000
Buffalo (Suburbs), N. Y.....	P	P	75.0	115.0	50-100	600-800	50,000	6,576,247
Burlington, Ia.*.....	P	P	4.0	48.48	25-100	0-171.5	24,324	2,250,000
Calcutta, India.....	M	P	21.0	360.0	20-120	.....	1,100,000	36,000,000
Cedar Rapids, Ia.....	M	P	8.0	66.0	60-120	.....	35,000	2,400,000
Charlotte, N. C.....	M	P	5.0	75.0	45-95 & 85-135	640-765	30,000	1,594,000
Cheyenne, Wyo.....	M	G	4.0	30.0	115-130	6030-6100	13,000	3,360,000
Chicago, Ill.....	M	P	.....	2400.0	25-60	.....	2,372,000	518,000,000
Chisholm, Minn.*.....	M	P	1.5	10.0	85-98	0-117	8,000	400,000
Clarksburg, W. Va.....	M	P	2.0	24.0	55-145	935-1160	15,000	2,535,000
Clarksville, Tenn.....	M	P	3.0	15.0	40-110	0-200	10,000	800,000
Corning, N. Y.....	M	P	3.1	27.14	4-100	918-1165	14,900	1,240,000
Council Bluffs, Ia.....	M	P	5.0	59.4	0-120	20-322	32,000	2,750,000
Clinton, Ia.....	P	P	5.87	50.43	50-100	.....	25,500	1,570,000
Dallas, Ore.....	P	G	4.0	13.5	85	Level	2,500	221,920
Daytona, Fla.....	M	P	9.0	11.58	43-90	6-25	3,000 S. 10,000 W.	130,000
Delaware, Ohio.....	P	P	.....	23.0	50-65	.....	9,000	1,055,000
Denver, Colo.....	P	P & G	59.5	533.0	45-100	0-310	220,000	43,400,000
Duluth, Minn.....	M	P	.....	145.0	10-135	5-800	75,000	8,000,000*
Edgeworth Water Co.....	P	P	2.014	12.3	8-117	720-915	3,358	358,000
Elmira, N. Y.....	P	P	9.23	97.7	65-140	.....	52,000	6,000,000
Elyria, Ohio.....	M	P	5.0	60.0	35-45	150-202	16,000	1,938,000
Erie, Pa.....	M	P	.....	143.0	15-120	0-307	72,000	15,700,000
Evansville, Ind.....	M	P	6.5	116.45	35-50	40-65	55,000	9,797,800
Eveleth, Minn.....	M	P	3.0	10.0	70-140	0-530	8,000	608,207
Everett, Wash.....	P	P & G	9.0	84.29	50-125	.....	25,000	3,103,940

CONSUMPTION COMMITTEE—1914

John N. Chester
Alexander Potter
H. J. Montoulieu

W. S. Cramer
E. E. Davis
E. S. Cole,
Chairman.

PER CENT ALLOWED PUMP SLIP	PER CAPITA DAILY	TOTAL TAPS	TOTAL METERS	PER CENT METERS	GALLONS PER DAY METERED REGIS- TRATION	PER CENT	MINIMUM NIGHT RATE	PER CENT OF DAY RATE	OFFICIAL REPORTING
10	11	12	13	14	15	15A	16	16A	
4.0	123.0	14,000	4,200	30.0			2,500,000	27.0	H. H. Frost, Supt.
	220.0	18,428	5,756	31.2					J. B. Kilbourn, Supt.
	37.3	13,215	680	5.15	777,200	37.5			C. B. Campbell, Secy.
20.0	140.0	7,027	655	9.33					C. H. Vinal, Supt.
	106.0	1,981	555	28.0	446,000	35.0	{ 520,000 ^{6 pm} 6 am }	41.0	Sam Wheeler, Supt.
7.8	150.0	8,300	750	9.0	1,450,000	22.2	4,500,000	22.7	J. Walter Ackerman, Engr.
	160.0	2,090	140	7.14	105,000	5.5			W. B. Getchell.
0	141.9	13,180	94	0.7	286,100	3.6	5,000,000	23.0	E. W. Meckley, Asst. Engr.
6.0	126.0	114,200	5,600	3.15	18,400,000	24.5	52,000,000	29.0	Robt. L. Clemmitt, Asst. Water Engr.
		2,357	1,954	84.1	930,000				Beloit Water, Gas & Electric Co.
3.0	60.0=	4,176	451	10.8	430,750	24.8			A. N. Bennie.
0	261.0		2				1,150,000	46.0	G. H. Bryson.
2.5	76.0	1,000	940	94.0	306,800	66.8	30% Est.	30.0	
	309.0	51,052	4,004	4.94	41,400,000	29.8			H. L. Lyons, Dep. Water Commr.
	131.5	3,211	3,247	100.0					Western New York Water Co.
6.2	92.6	4,445	200	4.5	882,000	39.2	1,250,000	55.0	Frank Lawlor, Supt.
4.0	33.0	150,000	2,361	1.57			6,600,000	18.3	Arthur Perin.
0	68.6	6,000	6,000	100.0					City Water Works.
	53.1		4,200				30%	30.0	W. E. Vest, Supt.
	259.0	1,600					2,500,000	74.0	R. D. Goodrich, City Engr.
9.0	218.0	277,000	16,960	6.1	118,000,000	22.8			W. J. McCourt, Supt.
10.0	50.0	700							C. J. Sullivan, Supt.
	158.0	2,700	40	1.5	1,000,000	39.5	50%	50.0	S. G. Highland, Secy. and Genl. Supt.
10.0	80.0	1,300	200	16.7					S. J. Lowe, Supt.
4.0	83.3	2,753	2,721	99.0	1,240,000	100.0	200,000	16.0	Wm. O. Drake, Supt.
2.0	86.0	6,100	4,000	75.5					S. L. Etnyre, Supt.
3.0	61.4	3,621	2,257	62.2	477,000	30.4			A. W. W. & G. Co.
	88.8	540	353	55.5					H. V. Gates, Dallas Water Co.
1.0	20.0=	478	478	100.0	113,550	91.2	96,000	74.0	Geo. A. Main, Supt.
5.0	117.6	2,100	1,056	50.4			50%	50.0	C. W. Wiles, Supt.
	197.0	44,500	300	0.67	3,750,000				C. F. Catchpole, Asst. Genl. Mgr.
	106.5=	10,900	7,525	69.0					E. W. Kelly, Engr.
5.0	106.6	700	687	98.4	166,360	46.5	119,280	33.3	Chester & Fleming, Engrs.
	115.0	8,073	3,902	48.4	1,690,000	28.2	2,000,000	33.0	F. D. Hill, G. M.
3.0	121.1	3,650	3,650	100.0	1,577,714	81.4	743,000	33.3	J. B. Daly, Ch. Clerk.
0	218.0	17,433	535	3.0	4,680,000	29.8	11,050,000	70.4	E. W. Humphreys.
3.0	178.0	10,000	50	0.5			6,500,000	66.4	W. H. Durbin, Gen. Mgr.
10.0	76.1	750	30	4.0					F. E. Forristel, Supt.
	111.0	5,489	213	3.9	1,063,000	34.2	2,000,000	64.4	

REPORT OF WATER

Col. 32 = $\frac{\text{Col. 9} - \text{Col. 21}}{\text{Col. 8}}$ Col. 33 = $\frac{\text{Col. 19}}{5}$

Note:

Col. 32 is correct only when Non Domestic Consumption is fully metered.

Col. 33 is correct assuming 5 persons per meter.

Note:

(A)—Metered houses, with two families or more, are classed as commercial.

* Includes commercial.

CITY	METERED DOMESTIC USE			NON-DOMESTIC CONSUMPTION				
	No. Meters	Gallons Daily Registration	Gallons per Day per Meter	Total			Industrial	
				No. Meters	Gallons Daily Registration	Gallons per Day per Meter	No. Meters	Gallons Daily Registration
	17	18	19	20	21	22	23	24
Akron, Ohio								
Albany, N. Y.								
Altoona, Pa.	396	61,200	154.5	284	718,000	2,520	27	334,000
Appleton, Wis.	572			83			111	
Ashland, Wis.	283	109,000	385.0	272	337,000	1,240	41	276,000
Auburn, N. Y.	0			750	1,453,000	1,937	115	732,000
Augusta, Me.								
Allentown, Pa.	13	7,100	546.0	81	279,000	3,444	37	191,000
Baltimore, Md.								
Beloit, Wis.	1,636	190,000	116.0	348	740,000	2,126	13	572,000
Biddeford and Saco, Me.	329	95,400	290.0	122	335,350	2,749	34	280,000
Brockville, Ont.								
Brunswick, Me.	854	95,800	112.0	86	211,000	2,453	10	186,000
Buffalo, N. Y.				4,004	41,400,000	10,340		
Buffalo (Suburbs), N. Y.	3,154	430,000	139.0	93	4,930,000	53,000	93	4,980,000
Burlington, Ia.				200	882,000	4,410		
Calcutta, India								
Cedar Rapids, Ia.								
Charlotte, N. C.								
Cheyenne, Wyo.								
Chicago, Ill.								
Chisholm, Minn.								
Clarksburg, W. Va.				40	1,000,000	25,000	40	1,000,000
Clarksville, Tenn.								
Corning, N. Y.	2,432	862,000	354.0	280	378,000	1,305	24	250,000
Council Bluffs, Ia.								
Clinton, Ia.	1,683 (a)	131,000 (a)	78.0	574 (a)	346,000 (a)	603	63	157,000
Dallas, Ore.				24			8	
Daytona, Fla.	410	66,800	163.0	68	51,750	760	59	45,500
Delaware, Ohio								
Denver, Colo.				300	3,750,000	1,250	251	1,538,000
Duluth, Minn.								
Edgeworth Water Co.	670	86,700	129.0	17	70,660	4,090	9	74,300
Elmira, N. Y.	3,857	650,000	169.0	45	1,040,000	23,100	45	1,040,000
Elyria, Ohio*	3,438	620,414	181.0		957,300		33	752,400
Erie, Pa.				545	4,680,000	8,750	535	4,680,000
Evansville, Ind.								
Eveleth, Minn.	0	0	0	17	255,800	15,000		
Everett, Wash.								

CONSUMPTION COMMITTEE—1914

John N. Chester
Alexander Potter
H. J. Montoulieu

W. S. Cramer
E. E. Davis
E. S. Cole,
Chairman.

NON-DOMESTIC CONSUMPTION							DOMESTIC PER CAPITA		OFFICIAL REPORTING
Industrial	Commercial		Public						
Gallons per Day per Meter	No. Meters	Gallons Daily Registration	Gallons per Day per Meter	No. Meters	Gallons Daily Registration	Gallons per Day per Meter	32	33	
25	26	27	28	29	30	31			
12,370	257	252,000	1,486				24.0	31.0	H. H. Frost, Supt.
	73								J. B. Kilbourn, Supt.
6,732	215			16	61,200	3,825	78.0	77.0	C. B. Campbell, Secy.
6,360	584	456,500	781	51	264,500	5,188	140.0		C. H. Vinal, Supt.
5,162	41	88,600	2,014				137.0	109.0	Sam Wheeler, Supt.
									J. Walter Ackerman, Engr.
									W. B. Getchell.
									E. W. Meckley, Asst. Engr.
44,000	305	94,900	311	30	73,100	2,436		23.0	Robt. L. Clemmitt, Asst. Water Engr.
8,235	63	42,600	677	25	12,750	510	41.0	58.0	Beloit Water, Gas & Electric Co.
18,000	75	25,000	329				41.0	22.0	A. N. Bennie.
	4,004	11,400,000	10,340				217.0		G. H. Bryson.
53,000							33.0	28.0	H. L. Lyons, Dep. Water Commr.
							56.0		Western New York Water Co.
									Frank Lawlor, Supt.
									Arthur Perin.
									City Water Works.
									W. E. Vest, Supt.
									R. D. Goodrich, City Engr.
		30,000							W. J. McCourt, Supt.
25,000							96.0		C. J. Sullivan, Supt.
10,420	232	108,500	430	13	22,250	1,712	58.0	71.0	S. G. Highland, Secy and Genl. Supt.
2,492	472(a)	119,000(a)	252	30	70,000	1,794	48.0	16.0	S. J. Lowe, Supt.
	12			4					Wm. O. Drake, Supt.
7,700	—Included in Industrial			9	6,270	697	12.0	33.0	S. L. Etnyre, Supt.
6,130	0	0	0	49	2,212,000	45,140	180.0		A. W. W. & G. Co.
8,255	3	1,100	370	5	4,250	850	83.0	26.0	H. V. Gates, Dallas Water Co.
23,100							96.0	34.0	Geo. A. Mann, Supt.
22,800	179	115,800	647		89,100		64.3	36.0	C. W. Wiles, Supt.
8,750							153.0		C. F. Catchpole, Asst. Genl. Mgr.
									E. W. Kelly, Engr.
				17	255,800	15,000	44.0		Chester & Fleming, Engrs.
									F. D. Hill, G. M.
									J. B. Daly, Ch. Clerk.
									E. W. Humphreys.
									W. H. Durbin, Gen. Mgr.
									F. E. Forristel, Supt.

REPORT OF WATER CONSUMPTION

CITY	MUNICIPAL OR PRIVATE	PUMPED OR GRAVITY	AREA SQ. MI.	MILES OF MAINS	RANGE OF PRESSURES	RANGE OF ELEVATIONS	POPULATION	GALLONS DAILY CON- SUMPTION
1	2	3	4	5	6	7	8	9
Fargo, N. D.	M	P	3.0	36.0	40-100	895-905	16,000	2,191,800
Fort Dodge, Ia.	M	P	4.0	26.0	35-110	0-150	20,000	1,000,000
Fort Smith, Ark.	M	P		50.5	45-150		28,000	2,531,000
Fall River, Mass.	M	P		118.0	80	129	115,400	5,334,000
Galt, Ont.	M	P	4.0	36.0	90-120	0-200	12,000	1,000,000
Gloversville, N. Y.	M	G		39.88	45-135		20,000	1,340,000
Grand Rapids, Mich.	M	P	17.5	203.0	15-105	5-200	90,000	15,832,500
Green Bay, Wis.	P	P		56.0	40-100		27,000	1,204,000
Hagerstown, Md.	P	G	10.0	53.0	26-58	552-620	20,000	2,444,800
Harrisburg, Pa.	M	P		91.0	30-84	310-430 L. S. 430-520 H. S.	70,000	8,390,600
Harvey, Ill.			2.25	18.0	40-90	Level	7,227	407,000
Holyoke, Mass.	M	G	23.0	92.67	65-105	60-380	80,000	6,780,000
Hollywood*	P	P	15.0	215.0	25-120	100-650	40,000	4,400,000
Hoquiam, Wash.	P	P	3.0	32.0	85-105	11-200	12,000	2,080,000
Havana, Cuba	M	P & G	12.0	250.0	15-45	0-250	400,000	55,000,000
Iron Mountain, Mich.	M	P	3.0	20.0	60-110		10,000	526,000
Jacksonville, Fla.	M	P		59.56	40-62.5	0-37	81,000	5,675,292
Jefferson City, Mo.	P	P	1.48	19.71	19-120	121-300	13,500	1,335,000
Jersey City, N. J.	M	G	29.2	225.0	25-70	1-70	300,000	44,000,000
Kokomo, Ind.	P	P	8.26	45.12	50-100		20,000	1,950,000
Keokuk, Ia.	P	P	4.875	30.62	50-130		14,000	1,488,000
Kalamazoo, Mich.	M	P	9.0	82.0	45-65	0-100	40,000	2,202,500
Kansas City, Mo.	M	P	50.0	542.0	30-150	22-300	280,000	32,973,000
La Grange, Ill.		P	2.0	70.0	40-90	Level	10,500	576,000
Lake Charles, La.	P		5.0	13.0	30-125	3-15	15,000	
Lancaster, Pa.	M	P	4.0	70.0	25-80		50,000	7,247,000
Lincoln, Ill.	M	P	3.0	22.0	36-51	20-46	7,300	651,138
Litchfield, Ill.	P	P	3.5	8.0	30-80	25-125	7,000	
Los Angeles, Cal.	M	P & G	107.6	872.6	20-130	160-870	516,300	51,700,000
Louisville, Ky.	P	P	25.0	387.36	40-75	450-550	214,000	25,545,246
Louisiana, Mo.	P	P	1.74	10.03	95-140		4,860	475,000
Lexington, Ky.	P	P	6.0	76.0	40-120	928-1019	40,000	2,483,742
Macon, Ga.	M	P	8.3	81.76	10-107	300-512	42,500	4,885,000
Madison, Wis.	M	P	4.0	75.96	50-85	0-125	27,000	2,127,000
Manchester, Vt.	P		3.0	12.0	65-125		1,500	64,000
Memphis, Tenn.	M	P	22.0	258.0	45-60	216-321	175,000	14,500,000
Marinette, Wis.	P	P	4.84	35.60	40-110		14,610	1,363,270
Meridian, Miss.	M	P		46.0	70-150	10-120	23,240	2,224,000
Merrill, Wis.	P	P	3.88	20.04	40-80		8,689	908,220
Manila, P. I.	M	G	16.0	116.0	30-40	5-15	265,000	13,500,000

COMMITTEE—1914—Continued

PER CENT ALLOWED PUMP SLIP	PER CAPITA DAILY	TOTAL TAPS	TOTAL METERS	PER CENT Meters	GALLONS PER DAY METERED REGIS- TRATION	PER CENT	MINIMUM NIGHT RATE	PER CENT OF DAY RATE	OFFICIAL REPORTING
10	11	12	13	14	15	16A	16	16A	
5.0	137.0	2,400	150	6.3	.....	.....	.....	.....	F. L. Anders, City Engr.
5.0	50.0	2,600	2,500	96.0	548,000	54.8	300,000	30.0	John W. Proy.
0	90.4	4,500	1,200	26.6	786,800	31.0	.....	.....	W. H. Bruce, Supt.
.....	46.2	9,505	9,289	97.8	4,219,000	79.0	.....	.....	J. J. Kirby, W. Registrar.
0	83.5	3,000	1,200	40.0	.....	.....	83,000	8.3	Scott Bartleman, Supt.
.....	67.0	3,966	3,630	91.5	.....	.....	.....	.....	.....
0	176.0	21,131	9,870	46.7	6,668,300	42.1	6,177,900	39.0	L. D. Cutcheon, Sec. Mgr.
0	45.0	4,745	3,500	73.8	.....	.....	.....	.....	J. P. Flatley, Supt.
.....	122.2	4,364	526	12.1	1,483,000	60.7	1,000,000	41.0	Albert Heard, Genl. Mgr.
3.0	120.0	17,579	11,544	65.5	.....	.....	.....	.....	E. B. Showell, Jr., Chem. & Bact.
.....	56.2	1,115	1,109	99.5	279,500	68.7	360,000	88.4	.....
.....	113.0	4,500	429	9.5	1,932,000	28.5	3,540,000	52.2	Patrick Gear, Supt.
.....	110.0	9,102	9,102	100.0	2,950,000	67.1	.....	.....	O. E. Wern, Sec.
6.0	173.0	1,950	400	20.5	.....	.....	.....	.....	Harry C. Heermans, Pres.
.....	137.5	25,250	178	0.7	1,077,500	1.96	44,000,000	80.0	H. J. Montoulieu, Ch. Engr.
10.0	52.0	1,505	683	45.0	201,420	38.4	210,400	40.0	E. A. Croll, Supt.
4.0	70.0	10,111	7,828	77.4	.....	.....	3,720,000	65.5	L. E. Murphy, Supt.
5.0	99.0	1,387	477	34.4	870,820	65.2	475,000	35.7	L. B. Landman.
.....	146.7	35,100	5,100	14.5	18,062,000	41.0	8,000,000	18.2	F. McCarren, Assessor.
3.0	97.5	3,831	329	8.6	323,000	16.6	.....	.....	A. W. W. & G. Co.
3.0	105.0	2,718	1,783	64.5	377,500	25.7	.....	.....	A. W. W. & G. Co.
2.0	55.0	.....	.....	.....	.....	.....	1,200,000	54.5	H. A. Watson, Supt.
5.0	122.0	53,783	30,718	57.0	21,900,000	66.0	.....	.....	S. Y. High, Supt.
.....	54.9	1,373	1,369	99.6	435,000	75.6	480,000	83.4	.....
.....	700	16	2.3	.....	.....	.....	.....	.....	F. V. Gallagher.
.....	121.0	13,000	4,500	34.6	2,600,000	35.8	2,500,000	34.6	John T. Brainard, Secy.
5.0	89.2	1,351	575	42.6	.....	.....	.....	.....	E. MacDonald.
.....	272	30	11.0	.....	.....	.....	.....	.....	David Davis, Mayor.
.....	136.1	74,361	53,000	77.9	.....	.....	.....	.....	Wm. Mulholland, Ch. Engr.
0	119.3	39,361	4,312	11.0	10,782,470	42.2	12,000,000	47.0	Theo A. Leisen, Ch. Engr. and Supt.
3.0	97.7	827	131	15.8	118,100	24.9	.....	.....	A. W. W. & G. Co.
4.0	62.1	5,206	5,206	100.0	2,370,000	95.35	1,050,000	43.5	W. S. Cramer, Ch. Engr.
9.8	115.0	6,475	3,495	54.0	1,060,800	34.0	1,090,000	34.6	Cliff T. Williamson.
0	79.0	5,775	5,733	99.2	1,348,587	63.4	300,000	14.1	E. E. Parker, Supt.
.....	43.0	392	271	69.0	56,650	88.5	.....	.....	A. B. Marsden, Treas. and Mgr.
.....	83.0	24,000	14,084	58.7	2,440,000	16.8	8,000,000	55.0	W. S. Willa, Genl. Supt.
3.0	93.3	2,815	114	4.1	126,224	9.2	.....	.....	A. W. W. & G. Co.
0	100.0	3,672	2,560	70.0	.....	.....	756,160	34.0	M. L. Worrett.
3.0	104.5	1,054	.....	.....	.....	.....	.....	.....	A. W. W. & G. Co.
.....	51.0	7,000	6,700	96.0	7,500,000	55.5	4,500,000	33.0	A. Gideau, Ch. Engr.

REPORT OF WATER CONSUMPTION

CITY	METERED DOMESTIC USE			NON-DOMESTIC CONSUMPTION				
	No. Meters	Gallons Daily Registration	Gallons per Day per Meter	Total			Industrial	
				No. Meters	Gallons Daily Registration	Gallons per Day per Meter	No. Meters	Gallons Daily Registration
	17	18	19	20	21	22	23	24
Fargo, N. D.								
Fort Dodge, Ia.	2,450	392,000	160.0	50	156,000	3,120	50	156,000
Fort Smith, Ark.	806	91,600	114.0	271	695,200	2,566	30	145,700
Fall River, Mass.		2,075,000			2,144,000			784,000
Galt, Ont.								
Gloversville, N. Y.	3,630	1,340,000	369.0					
Grand Rapids, Mich.	9,058	2,325,000	256.0	812	4,343,300	5,349	742	4,311,000
Green Bay, Wis.								
Hagerstown, Md.	0	0	0	526	1,483,000	2,820		1,220,000
Harrisburg, Pa.								
Harvey, Ill.								
Holyoke, Mass.	27	52,600	1948	402	1,879,400	4,675	193	963,000
Hollywood.	9,102	2,950,000						
Hoquiam, Wash.								
Havana, Cuba.				178	1,077,500	6,050	178	1,077,500
Iron Mountain, Mich.	635			48				
Jacksonville, Fla.								
Jefferson City, Mo.	315	46,410	147.0	102	824,420	5,090	22	716,400
Jersey City, N. J.	2,200	3,300,000	1500	2,900	14,362,000	4,950	1,718	13,007,000
Kokomo, Ind.	190	22,900	121.0	139	300,100	2,160	60	224,000
Keokuk, Ia.	1,373(n)	106,500(n)	77.6	380(n)	271,000(n)	713	31	146,500
Kalamasoo, Mich.								
Kansas City, Mo.								
La Grange, Ill.								
Lake Charles, La.								
Lancaster, Pa.								
Lincoln, Ill.								
Litchfield, Ill.								
Los Angeles, Cal.								
Louisville, Ky.	1,465	721,537	493.0	2,847	10,060,000	3,538		
Louisiana, Mo.	70	6,300	90.0	61	111,800	1,833	11	95,600
Lexington, Ky.		676,000			1,605,000			716,000
Macon, Ga.	3,442	356,500	103.6	53	1,304,000	24,600		
Madison, Wis.	5,050	945,000	187.0	683	413,587	605.5	79	157,087
Manchester, Vt.	254	36,105	142.0	19	20,550	1,081	4	14,213
Memphis, Tenn.	13,263	1,920,000	145.0	510	520,000	1,020		276,000
Marinette, Wis.	10	664	66.0	104	125,560	1,207	35	85,000
Meridian, Miss.								
Merrill, Wis.	24	1,800	75.0	13	7,917	609		2,923
Manila, P. I.								

COMMITTEE—1914—Continued

NON-DOMESTIC CONSUMPTION									
Industrial	Commercial		Public				DOMESTIC PER CAPITA		OFFICIAL REPORTING
Gallons per Day per Meter	No. Meters	Gallons Daily Registration	Gallons per Day per Meter	No. Meters	Gallons Daily Registration	Gallons per Day per Meter			
25	26	27	28	29	30	31	32	33	
3,120							42.0	32.0	P. L. Anders, City Engr.
4,855	215	480,000	2,233	26	69,500	2,673	66.0	23.0	John W. Proy.
	Included in Domestic				1,360,000		27.6		W. H. Bruce, Supt.
									J. J. Kirby, W. Registrar.
									Scott Bartleman, Supt.
							67.0	74.0	
5,810				70	32,300	462	127.0	51.2	L. D. Cutcheon, Sec. Mgr.
									J. P. Flatley, Supt.
		263,000					48.0		Albert Heard, Genl. Mgr.
									E. B. Showell, Jr., Chem. & Bact.
4,990	139	694,000	4,990	70	222,400	3,177	92.0		Patrick Gear, Supt.
									O. E. Wern, Secy.
6,050							135.0		Harry C. Heermans, Pres.
									H. J. Montoucheu, Ch. Engr.
				16					E. A. Croll, Supt.
									L. E. Murphy, Supt.
32,560	121	54,220	448	19	53,780	2,830	37.8	29.4	L. B. Landman.
7,570	1,100	55,000	500	82	1,205,000	14,700	98.8		F. McCarren, Assessor.
3,733	60	51,300	8,550	13	24,800	1,907	82.5	24.0	A. W. W. & G. Co.
4,726	336(a)	102,800(a)	306	13	16,700	1,285		15.5	A. W. W. & G. Co.
									H. A. Watson, Supt.
									S. Y. High, Supt.
									F. V. Gallagher.
									John T. Brainard, Secy.
									E. MacDonald.
									David Davis, Mayor.
									Wm. Mulholland, Ch. Engr.
							72.3	98.6	Theo. A. Leisen, Ch. Engr. and Supt.
8,601	47	8,180	174	3	8,020	2,673	75.0	18.0	A. W. W. & G. Co.
		642,000			337,000		19.7		W. S. Cramer, Ch. Engr.
							84.3	30.7	Chas. T. Williamson.
1,988	561	167,250	298	43	89,250	2,076	63.0	37.4	E. E. Parker, Supt.
3,554	8	3,610	454	7	2,707	387	28.9	28.4	A. B. Marsden, Treas. and Mgr.
					244,000		50.0	29.0	W. S. Walls, Genl. Supt.
2,430	63	35,770	568	6	4,710	785	85.0	13.0	A. W. W. & G. Co.
									M. L. Worrett.
		1,470		4	3,514	880	103.6	15.0	A. W. W. & G. Co.
									A. Gibson, Ch. Engr.

REPORT OF WATER CONSUMPTION

CITY	MUNICIPAL OR PRIVATE	PUMPED OR GRAVITY	AREA SQ. MI.	MILES OF MAINS	RANGE OF PRESSURES	RANGE OF ELEVATIONS	POPULATION	GALLONS DAILY CON- SUMPTION
1	2	3	4	5	6	7	8	9
Miles City, Mont.....	M	P	0.75	18.5	50-130	0-2350	6,000	850,000
Milwaukee, Wis.....	M	P	25.69	505.0	15-75	10-180	430,000	47,920,000
Monroe, Wis.....	M	P	1.5	9.5	30-75	50-115	3,000	228,000
Mount Vernon, Ind.....	P	P	2.78	15.38	80-110		5,800	735,616
Muncie, Ind.....	P	P	11.5	57.1	35-90		30,000	2,915,272
New York City, N. Y.....	M & P	P & G	181.3	2793.0	10-140	0-400	4,915,000	462,900,000
New Albany, Ind.....	P	P	3.0	45.0	75-80	25-275	25,000	2,000,000
New Castle, N. S. Wales.....	M	P			0-100	0-300	101,000	2,835,000
New Castle, Pa.....	P	P	13.2	77.60	80-160	800-1150	35,000	3,536,000
New Orleans, La.....	M	P	17.0	550.0	60-70	0-15	360,000	20,600,000
Norwich, N. Y.....	P	G	3.0	19.6	40-60	0-50	8,000	2,225,000
Oak Park, Ill.....	M	P	4.5	80.0	50-50	Level	26,000	1,790,000
Ogdensburg, N. Y.....	M	P	6.0	35.0	5-50	245-325	18,000	2,500,000
Omaha, Neb.....	M	P	28.0	274.0	20-135	0-290	170,000	18,990,692
Providence, R. I.....	M	P	18.28	402.0	26-97	6-200	267,000	17,680,667
Pasaden, N. J.....	P	G	7.4	73.5	44-100	10-158	75,900	4,710,000
Pine Bluffs, Ark.....	P	G	4.13	38.0	45-100		16,000	1,145,000
Philadelphia, Pa.....	M	P	65.0	1754.0	20-150	0-400	1,611,000	289,671,000
Plattsmouth, Neb.....	P	P	4.0	10.0	40-90	120-233	2,700	244,500
Port Arthur, Ont.....	M	P	2.5	38.0	70-114	617-814	18,000	2,612,500
Portsmouth, Va.....	P	P	17.7	143.86	40		75,000	4,867,486
Quincy, Ill.....	P	P	4.5	67.5	3-110	100-330	38,587	1,923,300
Racine, Wis.....	P	P	8.35	74.59	65-110		41,000	3,444,900
Rahway, N. J.....	M	P	2.5	23.75	45-48	0-30	10,000	1,827,000
Rensselaer, N. Y.....	P	P	2.0	20.0	50-120	10-200	11,000	1,540,000
Reno and Sparks, Nev.....	M	G	8.0	57.5	50-90	4500-4600	13,500	9,460,800
Richmond, Ind.....	P	P	4-5	48.0	40-110		23,000	2,615,175
Richmond, Va.....	M	P	7.5	163.0	10-86	6-210	120,000	13,861,245
Ripon, Wis.....	P	P	1.5	11.6	25-90	35-160	3,800	269,700
Rochester, N. Y.....	M	G	22.0	460.0	30-80	425-615	250,000	23,740,000
Rochester & Lake Ont. W. Co.....	P	P	9.5	80.21	40-225	250-660		3,690,000
Rockford, Ill.....	M	P	9.6	112.67	20-65	97-213	53,000	2,865,836
Scottsdale, Pa.....	P	P & G	6.0	35.1	25-100	1020-1140	8,560	2,074,000
Saginaw, Mich.....	M	P		117.0	45-80	0-30	29,800	9,878,000
St. Boniface, Man.....	M	P	17.2	24.5	56-64	685-703	14,500	355,200
St. Catherine, Ont.....	M	G	5.0	55.0	73-116	266-366	17,000	2,740,000
St. Joseph, Mo.....	P	P	23.3	147.2	90-110		89,403	9,000,000
St. Louis, Mo.....	M	P	61.37	962.0	35-125	15-180	730,000	82,100,000
Salt Lake City, Utah.....	M	G	49.6	227.0	65-198	4250-5000	100,000	18,616,328
San Diego, Cal.....	M	G	39.0	325.93	50-150	0-420	85,000	6,853,863

COMMITTEE—1914—Continued

PER CENT ALLOWED PUMP SLIP	PER CAPITA DAILY	TOTAL TAPS	TOTAL METERS	PER CENT METERS	GALLONS PER DAY METERED REGIS- TRATION	PER CENT	MINIMUM NIGHT RATE	PER CENT OF DAY RATE	OFFICIAL REPORTING
10	11	12	13	14	15	15A	16	16A	
.....	142.0	750	650	86.0	.....	.....	.....	.....	G. C. Pruth.
0	111.4	59,603	59,233	99.4	34,800,000	72.6	30,000,000	82.5	H. P. Bohman, Supt.
10.0	79.0	563	581	100.0	216,500	91.0	133,320	55.0	M. J. Gettings, Supt.
3.0	126.8	1,172	106	9.0	111,525	15.2	.....	.....	A. W. W. & G. Co.
3.0	97.2	3,742	887	23.8	774,583	26.5	.....	.....	A. W. W. & G. Co.
5.0	94.2	364,800	95,200	26.1	129,700,000	28.0	.....	.....	I. M. de Varona, Ch. Engr.
10.0	80.0	4,000	351	8.8	.....	.....	.....	.....	J. O. Emdria, Jr., Supt.
5.0	25.0	18,408	3,093	16.8	.....	.....	.....	.....	.....
3.0	98.2	7,753	6,017	77.7	1,591,200	45.0	.....	.....	A. W. W. & G. Co.
.....	57.2	40,200	40,100	99.7	11,800,000	57.3	.....	.....	G. G. Earl, Genl. Supt.
.....	278.0	2,063	15	0.7	.....	.....	.....	.....	J. M. Diven, Jr., Supt.
.....	60.0	5,750	5,750	100.0	1,690,000	94.4	800,000	44.5	H. P. T. Matte, Supt.
.....	138.9	3,000	6	0.2	.....	.....	1,750,000	70.0	H. A. Lord, Supt.
0	112.0	25,325	23,818	94.0	.....	.....	7,596,276	40.0	L. H. Marshall.
2.0	66.0	30,159	27,529	91.0	.....	.....	.....	.....	.....
.....	62.0	7,920	4,508	60.7	2,515,000	53.2	2,600,000	55.2	W. C. Hopper, Supt.
10.0	71.6	2,267	2,267	100.0	316,600	27.6	960,000	83.8	Byron C. Fowles, Supt.
.....	179.7	250,000	16,000	4.6	.....	.....	200,000,000	69.2	C. E. Davis, Chief.
2.0	90.5	570	208	36.4	74,150	30.3	12,000	.....	H. H. Sinclair, Supt.
.....	145.0	2,268	323	14.7	724,000	27.7	.....	.....	.....
3.0	64.9	10,503	862	8.1	1,711,700	35.2	.....	.....	A. W. W. & G. Co.
.....	50.0	5,538	3,725	63.8	1,323,600	68.8	.....	.....	W. R. Gelston, Supt.
3.0	84.0	7,649	5,574	72.8	1,783,500	51.6	.....	.....	A. W. W. & G. Co.
5.0	182.7	1,908	180	9.4	.....	.....	.....	.....	A. F. Kerstein, Supt.
2.0	140.0	1,900	150	7.9	162,000	10.5	.....	.....	R. S. Hineckley, Supt.
.....	701.0	2,300	0	0	0	0	.....	.....	L. O. Murphy, Local Engr.
.....	113.7	6,038	3,267	55.0	1,540,000	59.0	.....	.....	H. A. Dell, Treas.
.....	115.5	24,380	18,581	75.2	10,423,000	75.2	.....	.....	E. E. Davis, Supt.
5.0	76.2	700	121	17.3	40,140	13.8	134,460	47.0	W. E. Haseltine, Ripan L. & W. Co.
.....	95.0	44,000	43,888	99.5	16,645,000	70.0	10,000,000	42.0	Beekman C. Little.
.....	.....	3,279	3,279	100.0	3,878,000	99.0	.....	.....	Rochester & Lake Ontario Water Co.
4.33	54.0	9,305	8,652	93.0	1,643,600	57.4	.....	.....	Oscar E. Bulkley.
0	244.0	2,135	75	3.5	505,000	24.4	300,000	14.5	G. S. Cheney, Supt.
0	333.7	8,350	343	4.1	920,900	9.3	.....	.....	G. V. Chandler, Bookkeeper.
.....	24.5	.....	1,500	100.0	355,200	.....	.....	.....	M. P. Blair, City Engr.
.....	181.0	4,857	153	3.15	848,000	31.0	.....	.....	Alex D. Milne, Supt.
3.0	101.0	12,505	2,175	17.4	4,795,000	53.3	.....	.....	.....
7.0	112.5	112,124	7,500	6.7	26,000,000	31.7	60,000,000	73.0	Edward E. Wall, Water Comm.
.....	186.2	18,529	1,214	6.5	5,162,077	27.7	7,633,000	41.0	Chas. F. Barrett, Supt.
.....	80.6	14,153	14,153	100.0	5,530,000	80.8	.....	.....	.....

REPORT OF WATER CONSUMPTION

CITY	METERED DOMESTIC USE			NON-DOMESTIC CONSUMPTION				
	No. Meters	Gallons Daily Registration	Gallons per Day per Meter	Total			Industrial	
				No. Meters	Gallons Daily Registration	Gallons per Day per Meter	No. Meters	Gallons Daily Registration
	17	18	19	20	21	22	23	24
Miles City, Mont.....								
Milwaukee, Wis.....	40,629			50,233(n)	34,000,000(a)	574	15,500	18,300,000
Monroe, Wis.....	562	100,000	178.0		116,500		13	95,500
Mount Vernon, Ind.....	23	2,435	106.0	83	100,000	1,314	15	84,500
Muncie, Ind.....	536	73,668	1372.0	351	700,925	1,997	55	496,325
New York City, N. Y.....								
New Albany, Ind.....								
New Castle, Pa.....	5,321	501,200	94.0	696	1,000,000	1,565	74	838,300
New Orleans, La.....	36,256	6,035,000	166.0	1,680	5,785,000	3,443	Included in Comm	
Norwich, N. Y.....								
Oak Park, Ill.....	5,700	1,362,600	239.0	50	327,400	6,548	10	221,300
Ogdensburg, N. Y.....								
Omaha, Neb.....								
Providence, R. I.....								
Pasenic, N. J.....	4,700	1,198,000	255.0	108	1,317,000	12,190	94	1,280,000
Pine Bluffs, Ark.....	1,963	197,400	100.6	250	119,200	476.8		
Philadelphia, Pa.....								
Plattsmouth, Nev.....				205	74,150	358		
Port Arthur, Ont.....				280	724,000	2,586		
Portsmouth, Va.....	33	4,700	143.0	829	1,707,000	2,060	134	1,491,000
Quincy, Ill.....	2,893	414,500	143.0	832	909,100	1,093	136	623,300
Racine, Wis.....	3,863	283,500	73.0	1,711	1,500,000	876	128	1,094,000
Rahway, N. J.....								
Rensselaer, N. Y.....								
Reno and Sparks, Neb.....								
Richmond, Ind.....		218,000			1,331,000			905,000
Richmond, Va.....	16,597	1,782,166	107.4	1,984	8,640,833	4,355	783	3,865,760
Ripon, Wis.....	70	5,540	70.0	42	34,000	824	9	16,460
Rochester, N. Y.....	42,888	7,820,000	182.5	1,000	8,825,000	8,825	400	4,570,000
Rochester & Lake Ont. W. Co.....	3,147	520,000	165.0	132	3,358,000	25,420	132	3,300,000
Rockford, Ill.....								
Scottsdale, Pa.....	20	10,500	540.0	55	495,200	9,000	50	477,900
Saginaw, Mich.....	114	31,000	273.0	229	889,900	3,853	67	667,000
St. Boniface, Man.....								
St. Catherine, Ont.....				153	848,000	5,540	55	748,000
St. Joseph, Mo.....	775	135,000	175.0	1,400	4,660,000	3,329	135	3,593,000
St. Louis, Mo.....	1,945	2,191,694	1127.0	5,555	24,210,554	4,356	809	14,301,633
Salt Lake City, Utah.....	265	115,425	405.0	929			929*	5,046,652*
San Diego, Cal.....	11,985	3,072,000	256.0	2,168	2,458,000	1,134	200	615,000

NON-DOMESTIC CONSUMPTION

Industrial	Commercial			Public			DOMESTIC PER CAPITA		OFFICIAL REPORTING
Gallons per Day per Meter	No. Meters	Gallons Daily Registration	Gallons per Day per Meter	No. Meters	Gallons Daily Registration	Gallons per Day per Meter			
25	26	27	28	29	30	31	32	33	
1,180	57,429(a)	14,100,000(a)	245.5	254	2,500,000	9,840	32.4	.....	G. C. Pruth.
7,340							40.5	35.6	H. P. Bohman, Supt.
5,633	60	8,730	145	8	15,860	1,962	108.0	21.0	M. J. Gettings, Supt.
9,024	282	187,300	664	14	17,300	1,240	73.8	.....	A. W. W. & G. Co.
									A. W. W. & G. Co.
									I. M. de Varona, Ch. Engr.
11,324	602	225,000	374	20	26,700	1,335	68.0	19.0	J. O. Emdria, Jr., Supt.
ercial.	1,277	4,620,000	3,617	403	1,145,000	2,841	41.0	0.33	A. W. W. & G. Co.
									G. G. Earl, Genl. Supt.
									J. M. Diven, Jr., Supt.
2,213	25	41,800	1,672	15	64,300	4,287	56.2	48.0	H. P. T. Matte, Supt.
									H. A. Lord, Supt.
									L. H. Marshall.
13,620				14	37,000	2,643	44.7	51.0	W. C. Hopper, Supt.
							64.0	20.0	Byron C. Fowles, Supt.
							63.0	.....	C. E. Davis, Chief.
							105.0	.....	H. H. Sinclair, Supt.
11,127	651	121,400	187	44	94,000	2,150	42.0	28.6	A. W. W. & G. Co.
4,583	637	209,400	329	59	76,400	1,295	26.0	28.6	W. R. Gelston, Supt.
8,545	1,541	315,000	204	42	91,000	2,166	47.0	15.0	A. W. W. & G. Co.
									A. F. Kerstein, Supt.
									R. S. Hinckley, Supt.
		180,000			246,000				L. O. Murphy, Local Engr.
4,937	1,114	3,290,000	2,953	87	1,485,133	17,071	43.5	21.5	H. A. Dell, Treas.
1,829	30	12,440	415	3	5,700	1,900	67.0	14.0	E. E. Davis, Supt.
11,425	450	3,050,000	6,777	150	1,205,000	8,040	59.7	36.5	W. E. Haseltine, Ripan L. & W. Co.
25,000	—Included in Domestic.				58,000			33.0	Beckman C. Little.
					570,160				Rochester & Lake Ontario Water Co.
									Oscar E. Bulkley.
15,930	10	10,600	1,060	15	6,700	447	185.7	106.0	G. S. Cheney, Supt.
9,955	162	222,900	1,376				304.0	55.0	G. V. Chandler, Bookkeeper.
									M. P. Blair, City Engr.
8,500	65	100,000	1,540				111.0	.....	Alex D. Milne, Supt.
26,015	1,165	722,000	820	100	345,000	3,455	48.5	35.0	
17,078	4,515	8,844,434	1,959	231	1,064,489	4,608	79.0	225.0	Edward E. Wall, Water Comm.
5,432*				0				81.0	Chas. F. Barrett, Supt.
3,075	1,880	1,024,000	545	88	819,000 115,500 gals not metered	9,307	51.7	51.2	

REPORT OF WATER CONSUMPTION

CITY	MUNICIPAL OR PRIVATE	PUMPED OR GRAVITY	AREA SQ. MI.	MILES OF MAINS	RANGE OF PRESSURES	RANGE OF ELEVATIONS	POPULATION	GALLONS DAILY CON- SUMPTION
1	2	3	4	5	6	7	8	9
San Lorenzo, Cal.....	P	P	4.0	20.0	65-90	100-200	2,000	648,000
Shamokin, Pa.....	M	G	187	60.3	10-100	700-900	40,000	Not Meas- ured
Spokane, Wash.....	M	P	39.25	367.22	30-185	1-710	104,402	29,869,000
Springfield, Mass.....	M	G	38.0	205.31	80-144	70-205	99,457	10,712,000
Stockton, Cal.....	P	P	10.0	74.0	40-80	1-10	30,000	4,138,132
Streator, Ill.....	P	P	5.5	45.0	40-110	0-42	14,000	1,840,000
Sunbury, Pa.....	P	P	2.0	40.0	25-100	0-80	15,000	3,424,663
Sydney, N. S. Wales.....	M	P & G		1864.0	25-75	5-360	776,076	29,043,000
Tacoma, Wash.....	M	P & G	25.0	300.0	25-100	24-410	100,000	46,000,000
Tampa, Fla.....	P	P	7.5	77.5	40-110	0-55	65,000	4,365,000
Toledo, Ohio.....	M	P	27.0	280.0	30-75	0-20	185,000	18,457,844
Toronto, Ont.....	M			526.0	40-80	245-550	450,000	55,000,000
Troy, N. Y.....	M	G	7.0	115.4	30-140	26-405	70,000	20,000,000
Urban Water Supply Co.....	P	P		5.0	70-80	50-75		2,000,000
Utica, N. Y.....	P	G	15.0	182.0	40-100	400-650	95,000	7,480,000
Victoria, B. C.....	M	G	11.0	128.0	30-91	100-255	45,000	3,602,300
Walkerville, Ont.....	P	P	3½	24½	65-130	6-50	7,500	2,811,560
Washington, D. C.....	M	P & G	70.0	57.4	22-117	0-423	353,000	57,500,000
Waterloo, Ia.....	M	P	12.96	48.5	60-110	844-955	32,000	1,338,621
West St. Louis, Mo.....	P	P		292.0	20-120	0-360	50,000	2,750,000
Wichita, Kan.....	P	P	14.45	132.59	55		54,545	3,820,000
Wilkinsburg, Pa.....	P	P	12-15	150+	10-210	750-1300	80,000	8,567,000
Williamsport, Pa.....	P	P & G	10.5	87.61	30-65	21-88	40,000	5,000,000
Wilmington, Del.....	M	P	10.2	135.0	20-93	0-270	92,000	11,416,069
Wilmington, N. C.....	M	P	5.0	42.0	55-60	40-72	30,000	2,900,000
Woonsocket, R. I.....	M	P		63.0	50-120		47,500	1,529,000
Worcester, Mass.....	M	G		258.0	55-150	481	160,000	11,115,953
Yarmouth, N. S.....	M	P		30+	50-80	40-120	6,700	808,627
Yasoo City, Miss.....	M	P	5.0	14.4	5-110	100-341	6,796	500,000 +
Yonkers, N. Y.....	M	P	2.2	148.37	30-135	0-320	88,500	8,080,000
Yokohama, Japan.....	M	G	7.57	149.36	30-70	4-150	323,900	6,240,000

COMMITTEE—1914—Concluded

PER CENT ALLOWED PUMP SLIP	PER CAPITA DAILY	TOTAL TAPS	TOTAL METERS	PER CENT METERS	GALLONS PER DAY METERED REGIS- TRATION	PER CENT	MINIMUM NIGHT RATE	PER CENT OF DAY RATE	OFFICIAL REPORTING
10	11	12	13	14	15	15A	16	16A	
1-1½	324.0	800 5,800	12 60	1.5 0.9	444,000				Chas. M. Whiting, Secy. B. W. Haupt, Secy. Roaring Creek W. Co.
0	286.1	24,663	10,002	44.0	2,740,000	9.2			A. Lindsay, Supt.
	108.0	13,667	12,872	94.4	6,848,000	81.9	2,000,000	18.7	E. E. Lochridge.
4-10	137.9	5,915	665	11.2	757,184	15.3	1,880,000	40.8	J. W. Hall, Mgr. (Pac. Gas & Elec. Co.)
8.0	131.0	3,892	412	10.6	775,857	42.0	1,296,000	70.0	D. E. Hoggan, Supt.
0	228.0	2,374	64	2.7	1,945,000	55.8	1,250,000	36.5	Harry Landon, Supt.
	50.0	940,000	33,086	3.5	11,730,000	30.0			Charles W. Smith.
	460.0	15,688	1,824	11.6					Dr. Willis E. Everette.
3.1	67.0	8,903	1,021	23.5	1,166,000	26.7	3,312,000	75.9	
6.5	99.8	28,710	25,485	88.7	13,843,300	75.0	11,000,000	60.0	
	129.0	95,000	3,512	3.7					
	285.7	11,726	298	2.5	1,980,000	9.9			J. M. Diven, Supt.
4.0		18	15	100.0	1,918,000	95.9			S. B. Severson, Maspeth, L. I.
	78.7	12,821	12,729	99.3	6,150,000	82.2			Don. R. Sidle.
	80.0		9,200		2,352,940	65.3	74,636,800		
3-15	375.0	1,700	100	8.3	1,291,070	46.0	1,308,000	46.5	Walkerville W. Co., C. D. Brown, Secy.-Treas.
3.76	162.7	66,478	39,184	58.9	17,727,000	50.8	42,529,000	74.0	W. A. McFarland, Supt.
6.0	41.8	4,520	4,313	95.4	875,000	65.4	450,520	34.0	G. E. Shoemaker, Secy.
0	55.0	5,870	3,601	61.4					
3.0	70.0	7,092	3,083	43.5	850,000	22.2			
2.0	107.0	12,706	12,575	99.0	6,991,000	81.5			W. C. Hawley, Ch. Engr. Pa. W. Co.
	150.0	7,125	100	1.4	1,255,404	20.9			Williamsport Water Co.
	124.0	19,909	5,695	43.7	6,382,082	55.9	2,000,000	17.5	Edgar M. Hoopes, Jr.
	93.3	4,500	1,442	32.0					W. E. Merritt, Supt.
	32.2	3,625	4,466	95.6	1,315,000	80.0	445,210	29.1	Arthur F. Ballou, Supt.
	69.5	18,660	15,276	98.0	7,880,000	70.8			Geo. W. Bachelder, Commr.
10.0	120.7	3,674	4	0.10	14,310	1.8			Geo. H. Rohnston, Supt.
3.0	73.6	1,248	1,048	84.1					James G. Butler, Supt.
0	98.1	8,964	9,921	100.0	5,438,000	63.6			E. L. Peene, Supt.
	19.3	25,155	2,295	9.1			(?)31,321		S. Inone, Ch. Engr.

REPORT OF WATER CONSUMPTION

CITY	METERS USED DOMESTIC USE			NON-DOMESTIC CONSUMPTION				
	No. Meters	Gallons Daily Registration	Gallons per Day per Meter	Total			Industrial	
				No. Meters	Gallons Daily Registration	Gallons per Day per Meter	No. Meters	Gallons Daily Registration
	17	18	19	20	21	22	23	24
San Lorenzo, Cal				9			4	
Shamokin, Pa.				60	444,000			
Spokane, Wash	300	656,000	218.6	88	2,084,000	23,680	13	408,000
Springfield, Mass								
Stockton, Cal								
Streator, Ill	268	139,000	518.5	144	637,000	4,425	111	583,000
Sunbury, Pa				61	1,945,000	30,400	24	1,885,000
Sydney, N. S. Wales								
Tacoma, Wash	20			1,361			100	
Tampa, Fla								
Toledo, Ohio	24,803	7,535,000	223.2				682*	8,505,300*
Toronto, Ont								
Troy, N. Y							298	1,980,000
Urban Water Supply Co	8	274	34.0	7	1,918,000	274,000	6	1,918,000
Utica, N. Y.	12,379	1,065,000	159.0	350	4,190,000	11,950	300*	3,985,000
Victoria, B. C.	7,900	966,000	122.0				797*	1,303,540*
Walkerville, Ont				100	1,394,539	12,910	100	1,230,000
Washington, D. C.	20,566	3,885,000	189.0	3,113	13,842,000	4,440	230	6,200,000
Waterloo, Ia	3,700	305,263	98.7	613	509,710	831	547	417,900*
West St. Louis, Mo								
Wichita, Kan	2,259	235,000	104.0	824	615,000	748	30	117,700
Wilkesburg, Pa		2,030,000			4,955,000			4,765,000*
Williamsport, Pa.	0	0	0	100	1,225,404	12,254	100	1,225,404
Wilmington, Del.	8,437	2,107,434	250.0				258	4,274,648
Wilmington, N. C.								
Woonsocket, R. I.								
Worcester, Mass		2,985,000						2,492,000
Yarmouth, N. S.								
Yazoo City, Miss.	245	30,500	142.0					
Yonkers, N. Y.	9,051	2,400,000	265.0				170	3,038,000
Yokohama, Japan								

NOTE—* Includes commercial.

NON-DOMESTIC CONSUMPTION							DOMESTIC PER CAPITA		OFFICIAL REPORTING
Industrial	Commercial			Public					
Gallons per Day per Meter	No. Meters	Gallons Daily Registration	Gallons per Day per Meter	No. Meters	Gallons Daily Registration	Gallons per Day per Meter			
25	26	27	28	29	30	31	32	33	
	1			4					Chas. M. Whiting, Secy.
									B. W. Haupt, Secy. Roaring Creek W. Co.
31,400	50	180,000	3,600	25	1,496,000	59,840	266.0	437.0	A. Lindsay, Supt.
					364,380				E. E. Loochbridge.
5,252				33	54,000	1,630	86.0	104.0	J. W. Hall, Mgr. (Pac. Gas & Elec. Co.)
78,541	40	60,000	1,500	0			98.6		D. E. Hoggan, Supt.
									Harry Landon, Supt.
									Charles W. Smith.
	1,193			68					Dr. Willis E. Everette.
					49,250				
12,180*								45.0	
6,644									J. M. Diven, Supt.
319,667	1	55	55					7.0	S. B. Severson, Maspeth, L. I.
13,283				50	205,000	41,000	34.6	32.0	Don. R. Sidle.
1,635*				70	82,800	1,183	189.0	24.0	
12,300	Meters not used on Commercial.				61,070				Walkerville W. Co., C. D. Brown, Secy.-Treas.
27,348	2,654	6,632,000	2,500	229	920,000	4,017	123.6	38.0	W. A. McFarland, Supt.
764				66	91,810	1,391	26.0	20.0	G. E. Shoemaker, Secy.
3,923	761	426,000	560	33	71,300	2,162	58.8	21.0	W. C. Hawley, Ch. Engr. Pa. W. Co.
					190,000		45.0		Williamsport Water Co.
12,254							119.0		Edgar M. Hoopes, Jr.
16,568								50.0	W. E. Merritt, Supt.
									Arthur F. Ballou, Supt.
	—Included in industrial.				946,000		17.9		Geo. W. Bachelder, Commr.
									Geo. H. Rohnston, Supt.
								28.0	James G. Butler, Supt.
17,870								53.0	E. L. Poene, Supt.
									S. Inone, Ch. Engr.

DRY FEED OF CHEMICALS, IN WATER PURIFICATION

By W. F. MONFORT

Dry feeding of chemicals has been practiced in American plants to a considerable extent for more than ten years. At St. Louis in 1903 and 1904 the advantage of avoiding bulky solutions of iron sulphate and milk of lime was appreciated and the method adopted by which the chemicals were dumped at five minute intervals into dissolving (or slaking) tanks and the solution or suspension applied to the influent water without further control. Later (1908) this method was modified by the use of clock operated automatic scales for lime, and a modified orifice feed for iron sulphate. The latter consists of a vertical orifice discharging upon a cylindrical drum revolving at a constant speed. Under test conditions with crushed and screened material its operation was satisfactory and its error small.

At Lancaster, Pennsylvania, a device was introduced which is thus referred to in *Engineering Record*, September, 1907.

Originally designed for softening and coagulation with lime and soda ash, it was decided to make no change in hardness of the water, but to use alum and soda as dry powders which are thrown into the water by a distributing device actuated by a Poncelot undershot wheel operated by the water as it flows into the coagulating basin.

This was an adaptation of the principle involved in the Maignen apparatus (1884) for softening water by the use of a dry powder "Anti-calcaire."

Mr. Allen Hazen in *Engineering Record*, July 19, 1913, describes and illustrates a device for applying aluminum sulphate: A screw-conveyor is operated in the bottom of a hopper by a motor (electric or water). Variations in the speed of the screw are controlled, first, by a system of multiple gearing admitting of easy and wide change and, second, by changing the speed of the motor. This apparatus designed in 1907 by Mr. Hazen for Brisbane, Australia, was worked out in its mechanical details by Mr. R. S. Weston, who installed a copy at Knoxville, Tennessee. Mr. Hazen states

that similar apparatus has been installed in a number of other plants with which he has had to do, and mentions the practical working of the device with aluminum sulphate and experimental success with calcium hypochlorite by the introduction of an "arrangement similar in construction to a meat chopper in the bottom of the hopper, above the screw, and operating it by the same motive power as the screw," to break up lumps and reduce the material to a size that can be handled by the screw.

In 1910 Mr. W. Donaldson devised an apparatus in which friction drive of a worm gear actuates the screw, permitting a nice adjustment of the weight of substance delivered through a wide range. Nine of these devices are in use in seven plants; eight, for applying hydrated lime, and one for sulphate of iron. Attempts to use it for soda ash have been unsatisfactory. Mr. Donaldson has made no publication concerning the apparatus, which seems worthy of a detailed description.

The matter of dry feed has been in the minds of many water works men for a number of years. What has been the genetic relation between the various developments mentioned, the writer will not undertake to say. It is probably true that the question has been in the air for a long period, and has received a wider consideration than any one has realized.

Perhaps some standardization of these devices may come about, such as has occurred in other apparatus for water treatment, filter control and the like, so that each user may not find it necessary to design throughout an apparatus for his particular need. In very large plants automatic scales are practical, as experience at St. Louis has demonstrated. For plants of medium and small size, dry feeding has proved feasible in a number of cases.

Regarding the measure of success which may be hoped for in any instance, the physical character of the material plays an important part. Mr. Hazen calls attention to the necessity of having sulphate of aluminum crushed to a smaller size than that ordinarily used, that it may be fed dry, and to the difficulty with calcium hypochlorite on account of its physical properties. It may be of interest to call attention to those specific properties of substances in common use, which affect their adaptability to this method of application.

The properties of a substance which affect its storage are closely related to the success of feeding devices. A model substance for

application in this way should be uniform in size, constant in composition, permanent under prevailing conditions of temperature and pressure, and neither hygroscopic nor efflorescent.

Perhaps the most remote from this is calcium hypochlorite; because of its instability, its disagreeable odor, and its tendency to take up moisture, all of which connote loss of efficiency, as well as the mechanical difficulty of feeding regularly a more or less moist and lumpy material, dry feed for hypo seems impracticable.

Aluminum sulphate if fairly fine and uniform gives no trouble. It is stable at prevailing temperatures, not hygroscopic, does not cake, or bridge readily. Especially advantageous is dry feeding, as reducing to a minimum the corrosive action of a solution on pipes which convey it.

Hydrated lime of good quality for water treatment is now a commercial product, costing more of course than its equivalent of lump lime. But in many instances this excess would be almost or wholly met by the general simplification of the plant and the lowered cost of attendance.

As now manufactured it is air-separated and so uniform in size that 99.68 per cent will pass a 100-mesh, and 97.98 per cent a 200-mesh sieve. That it has a tendency to bridge over an orifice is a difficulty which has to be met where automatic scales are used in filling it into bags at the place of manufacture, as well as in the dry feed apparatus. The same trouble occurs with any fine amorphous material. Deterioration is proportional to the pressure of carbon dioxide to which it is exposed. This is ordinarily very small, save for purely local conditions. Because of its great uniformity it is especially well adapted to dry feed.

Lump lime is applied with automatic scales at St. Louis and at Columbus. The difficulty of adapting the scales to closely control coarse and fine material has not been wholly overcome. It is impossible to crush this material without fines, and wasteful to eliminate them. But the fines bridge as badly as hydrated lime, with resultant overloading and overdosing. Still a great improvement has been made within the past six years, and the method may be accounted successful. The storage problem in handling large quantities of lime is associated with the mechanical rather than with the chemical side, in that the upkeep of conveying machinery is the serious feature rather than deterioration in quality. If kept in bins that are practically air tight no deterioration occurs. It has

long been known that carbonation occurs at ordinary temperature only after hydration. If, therefore, access of moist air into this material is prevented, carbonation prior to slaking will be nil. Dry feeding to slaking tanks discharging directly into the water to be treated has the advantage of space economy and of freedom from incrustation in pipe systems with troublesome stoppages.

With iron sulphate a difficulty arises in the physical behavior of the substance under temperature conditions occurring at some time during almost every day from June to late September. The ordinary pure sulphate contains seven molecules of water of crystallization. In behavior it is similar to copper sulphate, which furnishes the stock illustration of the Phase Rule to crystals of hydrated salts. It has been shown by Hofman and Wanjukow that at 21°C. (70° Fahr.) in a stream of air this crystal form loses three molecules of water and passes over into pale green crystals having but four molecules of water ($\text{FeSO}_4 \cdot 4\text{H}_2\text{O}$) which at 80°C. (176° Fahr.) lose three molecules, undergo a transformation at 132°C. and begin to be oxidized very slowly at 167°C.; oxidation continues with the rise to 455°C. when conversion to $\text{Fe}_2\text{O}_3 \cdot 2\text{SO}_3$ is complete, and the last molecule of water is expelled.

This first transition to $\text{FeSO}_4 \cdot 4\text{H}_2\text{O}$ occurs to a limited extent in summer shipment in bags or in bulk, so that the material has a green gray appearance commonly. The extent to which alteration occurs does not greatly change the composition, only making analyses show a trifle more than 100 per cent of ferrous sulphate, ($\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$). But the slight efflorescence of exposed layer serves to inoculate the whole mass with the lower hydrate, facilitating the transformation.

If such a mass is stored in a closed bottle or other container at a temperature of 21°C. or slightly higher the resulting loss of water of crystallization in one part gives rise to a new trouble. The water vapor given off in the warmer layer is lighter than air; condensing on cooler particles, it is taken up by some pale green particles of the lower hydrate and in their re-crystallization in contact with other dark green ordinary crystals there is a cementing into masses of considerable size.

When iron sulphate is stored in large bins which are dust proof and almost air tight, a similar condition occurs. At St. Louis the bins are 20 feet in diameter and 40 feet deep. There have been times within the past six years when the whole content of a bin

was in one mass. Again the bottom portion might be less firm than the upper, so that a cylindrical portion was supported over an air filled space below; or an opening about two feet in diameter remained surrounded by a cylinder whose walls were nine feet thick. Even in a smaller bin which was refilled at frequent intervals this caking occurred to such an extent that its effective holding capacity was limited to a nearly cylindrical vertical opening through the central portion. However, this caked material lost nothing but a modicum of water, and had suffered a concentration rather than a deterioration, since it has been shown that oxidation occurs only at high temperatures.

With a well designed crusher it can be prepared for dry feeding. It is necessary that a fair degree of uniformity be given this as any other material which is to be fed through an orifice. In July to September of 1913 when caked material was imperfectly crushed and fed, analyses of the solution checked against the volume of water (metered) gave results ranging as low as 45 per cent. The results were obtained with an orifice, where material and voids are measured together, and with material that was coarse, with more or less abundant lumps of all sizes.

It is therefore important in using dry feed for iron sulphate, that the material be fairly uniform or freshly crushed and fed from a small open hopper frequently filled. Under these conditions, which will be readily met in a plant of medium size, iron sulphate may be successfully fed, for the difficulties mentioned arise from storage in large bulk. In bags which permit the escape of liberated water vapor, serious caking from this cause has not been observed. It is probable that shallow bins open to the air would be less subject to troublesome caking than the deep and relatively narrow ones here referred to. Whether a dry feed machine or automatic scales are used should be determined by the size of the plant. For large plants undoubtedly the scales are best adapted as being less sensitive to size variation than an orifice device or a screw conveyor.

Whatever method of feeding iron sulphate be adopted consideration should be given to the possibility of growth of algae in the solution. So far as the writer is aware this has not been discussed, although doubtless others have noted such growth in moderately strong solutions of this neutral salt, as well as the common development in iron bearing waters carrying but a few parts per million of iron. In a solution of one and one-half pounds sulphate of iron

per gallon, equivalent to more than 3700 parts of iron (Fe) per million, the growth at and near the surface was heavy and of such consistency that lumps of it breaking loose from the tank walls were firm enough to clog the outlet. It is inexpedient to use long pipe systems in conveying a solution in which such a growth may develop.

It is apparent that each substance presents the virtues and defects of its properties. It is essential that these be recognized and considered in adopting a method of feeding. Dry feed for alum, lime and iron sulphate offers certain advantages in permitting a reduction in the extent of pipes and the number of valves and fittings exposed to corrosion, incrustation, or stoppage from growths; economy of space in plant arrangement; a possible economy of attendance, and ready control of applied chemicals.

MAINTENANCE OF THE WATER SUPPLY DISTRIBUTION SYSTEM OF NEW YORK CITY

PRESENTED AT MEETING OF NEW YORK SECTION OF THE AMERICAN WATER WORKS ASSOCIATION, THURSDAY, DECEMBER 3, 1914.

BY WILLIAM W. BRUSH

Engineers are prone to give first place to the construction of new works and consider that the maintenance of engineering works does not present problems of equal importance or interest. Such an attitude is unfortunate, and is generally based on a lack of knowledge of the magnitude of maintenance problems and the opportunities in maintenance work for the display of engineering and organizing ability of the highest order.

One of the results of the engineer's failure to appreciate the proper position of maintenance work in the engineering field is the relatively few papers published on this subject. The difficulty of obtaining data on organization and methods in use in large maintenance operations is strong testimony to the truth of the above statement. The writer has, therefore, prepared the following description of the maintenance of the distribution system of New York City, believing that more published information on such subjects would be helpful to the profession.

The distribution system of New York covers an area which is 35 miles long and 20 miles broad, and divided by canals, rivers and bays which have to be crossed by the distribution mains. A number of islands having a population varying from a few hundred to several thousand must also be supplied, and add to the complexity of the problem. See Diagram No. 1.

Eight distribution reservoirs of a total capacity of 2500 m.g., with surfaces varying from 119 feet to 250 feet above tide level, and eight stand pipes, with overflows varying from 140 feet to 453 feet above tide level, are used to equalize the flow to the fourteen separate services in the five boroughs. See Table No. 1. Excluding tunnels and masonry conduits, there are 2800 miles of mains of sizes

varying from 4 inches in diameter up to 60 inches in diameter, to which are connected 60,000 valves, 43,000 hydrants and over 360,000 services. The details are given in Table No. 2. Over 500 m.g.d. are delivered through this system.

The services for each borough are shown on the accompanying diagram, No. 2, which indicates both the area supplied and the

TABLE 1
Watersheds—areas, capacities, drafts, etc.

WATERSHEDS	AREA OF WATERSHED SQ. MI.	SAFE YIELD M.G.	POINT OF DISTRIBUTION	CAPACITY MILLION GALLONS	ELEV. OF POINT OF DISTR.	PRES- ENT DRAFT FROM WATERSHED M.G.D.
Croton.....	360	336	Jerome Av. Tower	0.039	303	329
			Jerome Park Res.	773.000	134	
			High Bridge Tower	0.045	336	
			High Bridge Res.	11.000	218	
			Central Park Res.	1200.000	119	
Bronx and Byram.....	22	15	Williamsbridge Res.	140.000	197	18
Brooklyn....	New 97 Old 71	150	Ridgewood Res.	304.000	172	134
			Mt. Prospect Res.	19.185	200	
			Mt. Prospect Tower	0.112	280	
Queens, 3rd Ward.....	Driven well system. Makes water- shed lim- its indefi- nite.	6	College Pt. Stand- pipe	0.895	192	15
			Flushing Standpipe	0.800	221	
			Ridgewood Res.†	304.000	172	
Richmond....		9	Tottenville Stand- pipe	0.140	143	12
			Grymes Hill Stand- pipe	0.220	453	
			Third Ave. Res.	0.800	212	
			Clove Res.	2.900	254	

* Datum = Mean sea level at Sandy Hook.

† Brooklyn system furnishes about 10 m.g.d. to 1st Ward.

elevation of reservoir or stand pipe controlling the hydraulic gradient. In addition to the domestic system, there are three separate high pressure fire systems covering over 7200 acres with 170 miles of mains from 8 inches to 24 inches in diameter, on which are located 4100 hydrants and 6650 valves.

To the existing system there is to be added in about a year the great Catskill system, with its 17 miles of rock tunnel, 22 feeding

TABLE 3
Distribution mains, valves and hydrants in place—1914

	MANHATTAN AND BRONX	BROOKLYN	QUEENS	RICHMOND
<i>inches</i>	<i>feet</i>	<i>feet</i>	<i>feet</i>	<i>feet</i>
Mains				
60.....	800	.....	.....	.....
48.....	245,000	166,000	.....	.....
36.....	281,000	61,000	.....	.....
30.....	54,000	89,000	46,000	16
24.....	13,000	42,000	42,000	53,000
20.....	529,000	371,000	38,000	59,000
16.....	34,000	266,000	35,000	50,000
14.....	2,000	3,000	7,000	11,000
12.....	245,000	562,000	250,000	263,000
10.....	14,000	20,000	32,000	29,000
8.....	148,000	69,000	440,000	270,000
6.....	3,345,000	2,122,000	303,000	302,000
4.....	133,000	137,000	42,000	307,000
Total.....	5,043,800	3,908,000	1,235,000	1,344,016
Valves				
48.....	65	24	.....	.....
36.....	111	69	.....	.....
30.....	45	82	9	.....
24.....	21	77	11	.....
20.....	555	702	62	80
16.....	31	656	28	50
14.....	.....	1	9	21
12.....	6,763	1,629	703	304
10.....	10	7	45	41
8.....	551	4,813	1,233	917
6.....	19,936	14,044	2,020	2,262
4.....	375	134	34	1,031
Total.....	28,463	22,238	4,154	4,706
Hydrants				
Total (all patterns) ..	20,125	17,782	2,798	2,593

shafts, and 16 miles of delivery mains, varying on land from 48 inches to 66 inches in diameter, and including two miles of 36 inch submerged pipe, connecting Brooklyn with Richmond.

HUD



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1900-01
1901-02
1902-03

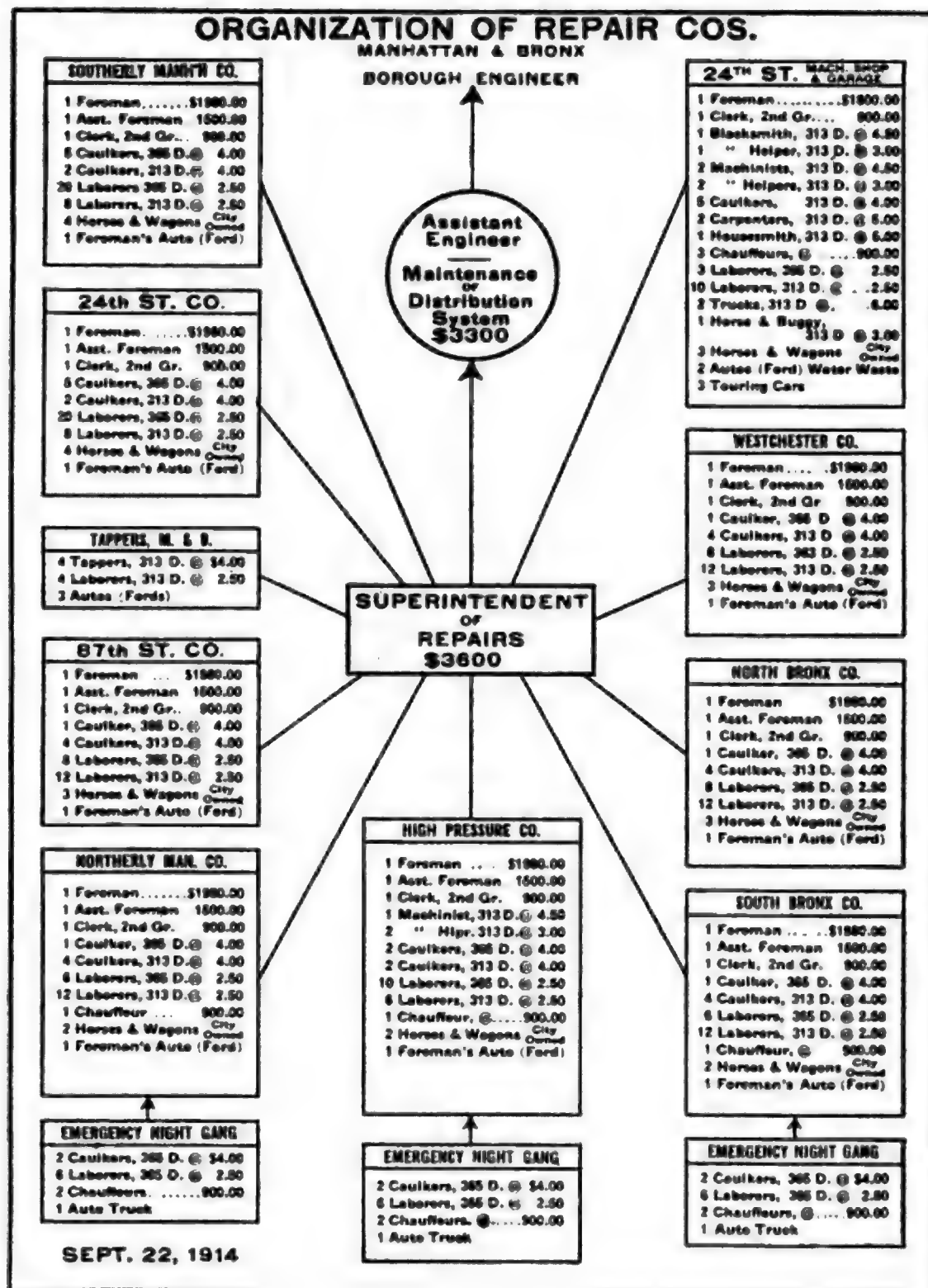


TABLE 3
Repair companies—Area covered and cost of payroll per hydrant and per mile of main

REPAIR CO.	NO. MEN		PAYROLL	AREA COVERED (SQ. MILE)	MILES OF MAINS = 12" MAIN	NO. HYDRANTS	NO. VALVES	COST PER MILE	COST PER HYDRANT
	Skilled	Unskilled							
Manhattan and Bronx									
Worth Street.....	7	36	50,675	3.3	113.5	2744	3201	\$446	\$18
35th Street.....	5	28	35,355	2.1	107.5	1625	2085	329	22
24th Street.....	2	30	37,259	2.1	97.7	1916	2440	381	19
87th Street.....	3	26	32,954	7.4	254.2	2945	3304	130	11
Harlem.....	3	30	37,155	5.0	365.2	2791	3137	102	13
Ft. George.....	1	13	16,367	2.1	48.9	831	1212	335	20
South Bronx.....	2	35	40,732	8.8	167.7	3567	4290	243	11
North Bronx.....	2	27	31,951	9.3	175.7	1847	2532	182	17
Westchester.....	3	17	22,978	22.1	93.0	1787	2079	247	13
High Pressure.....	2	23	27,999	5.8	126.1	2369	4062	222	12
Brooklyn									
Western District.....	9	73	78,726	13.5	353.0	5514	6866	223	14
Eastern District.....	4	47	48,260	6.54	158.0	2786	4637	305	17
East N. Y. Dist.....	5	44	48,822	10.56	173.0	2494	2509	282	20
Coney Island.....	3	36	45,975	24.1	219.0	6316	5789	210	7
High Pressure.....	1	10	10,825	4.8	51.0	1247	1727	212	9
Queens									
First Ward.....	2	23	22,318	8.0	80.0	1229	1224	278	18
Third Ward.....	1	18	17,401	34.0	90.0	1197	2203	192	15
Richmond									
West New Brighton.....	1	14	14,213	13.4	175.0	2332	4282	242	18
Clove.....	1	14	14,003	23.0					
Tottenville.....	1	10	10,398	21.0					



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Plate No. 1 shows the ground and second floor plan of the East New York headquarters in Brooklyn, and Plates Nos. 2 and 3 are photographs of this building which is nearing completion.

Plate No. 4 is a photograph of the 24th Street Station, which serves as headquarters for a repair company, the meter testing shop, garage, blacksmith shop, machine shop and store yard.

Headquarters, such as that erected at East New York Station, cost about \$25,000, exclusive of land, and can adequately provide for a force of forty men, six horses and six wagons, or automobiles. Space is provided under the sheds for the storage of valves and hydrants, it being expected that pipe and special castings would be stored in the open.

Equipment, Materials and Supplies

There is a natural tendency to hoard articles which may at some time be useful and which one may have had difficulty in obtaining in the past. Foremen in charge of repair companies have this very human trait, and the resulting accumulation of useful and useless material makes for confusion and inefficiency. As a corrective, a standard quota is set up for each repair company, the same quota being used where companies are of approximately equal size. This quota represents the equipment, materials and supplies, that should always be on hand, plus about one month's consumption of the materials and supplies. After such quota has been fixed, the surplus at each headquarters is removed and sent to a central storehouse, where it is placed in stock, or consigned to the scrap heap, if it is useless. At approximately the end of the month, the clerk makes a list of all equipment, materials and supplies consumed during the month and requisitions the storekeeper for such articles to replenish the depleted quota. If there is any unusual demand, the quota can be replenished at any time.

The tentative quota of equipment as shown in Table No. 4 may be useful for those who are setting up a similar standard.

Standardizing Materials, Pipe, Valves and Hydrants

All materials are purchased under definite specifications and are subjected to chemical and physical tests to determine compliance with standards. Samples are used as standards where it is difficult, if not impossible, to set up definite specifications.







TABLE 4

*Standard quota of equipment for repair companies.**Manhattan and the Bronx*

February 8, 1915

For office use:

Mops, complete.....	2
Mop wringer.....	1
Whisk brooms.....	2
Duster.....	1
Corn brooms.....	2
Fire extinguishers.....	2
Ash cans.....	2

For shop use:

Buck saw.....	1
Saw horse.....	1
Garden hose, feet.....	50
Step ladder.....	1
Platform scale.....	1
Anvil.....	1
Kerosene cabinet.....	1
Iron rake.....	1
Work bench.....	1
Vice (combination).....	1
Breast drill.....	1
Stock and dies (for pipe thread).....	3
Stock and dies (for machine thread).....	3
Ratchet brace and set of bits.....	1
Draw knife.....	1
Spirit level.....	1
Grindstone.....	1

For general use:

Rubber boots (for each man)	
Rubber hats (for each man)	
Oil suits for all, except foremen	
Rubber coat for each foreman	
Axes, 3-pound.....	3
Axes, 5-pound.....	3
Hatchets.....	3
Aquaphones.....	2
Crow bars, 6-foot.....	3
Telegraph bars, 6-foot.....	3
Pinch bars, 4-foot.....	2
Cutters (bull point).....	12
Brushes (casting).....	3
Cutters (asphalt).....	12
Hook chains, $\frac{1}{4}$ -inch x 12 feet.....	2
Hook chains, $\frac{1}{4}$ -inch x 12 feet.....	2
Cutters, pipe.....	2

TABLE 4—Continued

For general use—Continued:

Derrick, 1-ton.....	1
Derrick, 2-ton.....	1
Rope chain slings.....	2
Rope slings for 12-20 and 36-inch pipe, 2 of each.....	2
Files, 8-10 and 14-inch, 3 each of the following, bastards, half round, hand and square, second cut (flat).....	3
Files, saw (8-inch).....	3
Hydrant pressure gauges and connections.....	6
Striking hammers.....	6
Malls.....	2
Mortar hoes.....	2
Water hose, 2½-inch, feet.....	50
Hydrant pumps.....	2
Furnace (plumber's).....	1
Furnace, 18-inch caulker's.....	1
Gate keys (different lengths).....	12
"Wells" lights.....	2
Lanterns, dozen.....	5
Search lights (electric).....	2
Ladles, 9-inch.....	2
Ladles, 7-inch.....	2
Pouring pots and hooks.....	2
Melting ladles and tripods.....	2
Ditch pumps (G. I.).....	2
Dia. pumps, No. 2 (complete).....	2
Dia. pumps, No. 3.....	2
Dia. pump, gas driven.....	1
Picks, dozen.....	1
Pails (G. I.).....	6
Rammers.....	6
Asbestos joint runner, 48-inch.....	1
Asbestos joint runner, 30-inch.....	1
Asbestos joint runners, 20-inch.....	2
Asbestos joint runners, 12-inch.....	2
Asbestos joint runners, 8-inch.....	4
Asbestos joint runners, 6-inch.....	4
Shovels (D. handle R. P.).....	15
Shovels (L. handle R. P.).....	4
Shovels (D. handle sq. p.).....	6
Shovels (L. handle sq. p.).....	6
Telegraph spoons.....	2
Screw drivers, 24-inch.....	4
Screw drivers, 6-inch.....	2
Sledges, 24-pound.....	3
Sledges, 20-pound.....	3
Wheel tool box.....	1

TABLE 4—Continued

For general use—Continued:

Trowels.....	3
Tape, 50-foot.....	2
Rule, folding.....	6
Pipe vise (portable).....	2
Street brooms.....	6
Wrenches (monkey, 6- to 18-inch).....	9
Wrenches (Stillson 8- to 26-inch).....	9
Wrenches, hydrant.....	12
Wrenches, special for various makes of hydrants.....	
Saw, two-man.....	2
Saw, cross-cut.....	2
Saw, hack.....	3
Pliers, 4-inch, pairs.....	3
Pliers, 12-inch, pairs.....	3
Tin snips, pair.....	1
Soldering iron (1-pound).....	1
Extra length of 2½- and 3-inch suction hose with strainer, each.....	1
Caulking tools and implements (for each caulker employed).....	
Hammer.....	1
Yarning irons.....	2
Chisels (small bursting).....	2
Chisels (lifting).....	2
Chisels (cold).....	2
Chisel (dog).....	1
Chisel (dog diamond point).....	1
Chisels (hand diamond point).....	2
Wedges, large bursting.....	2
Hammer (3½-pound).....	1
Tool bag.....	1

The sizes of pipe used are 6-inch, 8-inch, 12-inch, 16-inch, 20-inch, 24-inch, 30-inch, 36-inch, 48-inch, 60-inch, 66-inch. For sizes above 48 inches steel is generally used; while for 48 inches and smaller sizes, cast iron is adopted. The pipe and specials are made from department designs, although the writer believes that a change to American Water Works Association standards for the pipe at least, will be made before long.

Valves are made from department design under definite specifications. The sizes adopted are 6-inch, 8-inch, 12-inch, 20-inch, 36-inch and 48-inch. Intermediate sized mains have valves with reducers. Thus, 36-inch valves are used on 48-inch and 36-inch mains, 20-inch valves on 30-inch, 24-inch and 20-inch mains, 12-inch valves on 16-inch and 12-inch mains. This practice requires

fewer valves in stock, greater ease and speed in operation of valves and less parts for repairs. The additional loss in head, due to contraction of waterway is negligible. Thus, with a velocity in the main of three feet per second, the loss at the valve, due to placing a 20-inch valve on a 30-inch main, is about a half an inch, while the frictional loss per 1000 feet would be about a foot. As valves are only placed at intervals of about 2000 feet on the larger mains the effect is not practically measurable.

The use of department designed valves has not materially increased the cost, as the prices quoted for valves delivered during the past year have been approximately as follows: these valves being a heavy bronze stem bronze mounted type:

<i>Size In.</i>	<i>Av. Cost</i>	<i>Size In.</i>	<i>Av. cost</i>
4	\$8.00	12	\$31.00
6	12.00	16	65.00
8	18.50	20	115.00

The hydrants used are also manufactured from department drawings and specifications. The body is 8 inches in diameter, with one 2½-inch and one 4½-inch outlet. These hydrants manufactured of high grade materials, and under careful inspection are now delivered at less than \$25 per hydrant.

To receive all equipment, materials and supplies, and care for same before use, three general store yards have been established, one in Manhattan to serve Manhattan, The Bronx and Queens, and one each in Brooklyn and Richmond to serve those boroughs. For pipe, special castings and other heavy materials additional yards have been established in each borough.

Machine Shops

Repairs to valves, hydrants and other appurtenances require machine work which is carried out in a well equipped shop in Brooklyn, where eight machinists and an equal number of helpers are employed. In Manhattan, less work of this character is performed by the city force, and only two machinists and helpers are assigned to distribution work. The Brooklyn shop is headquarters for the automobile repairs and as the department has over thirty cars with approximately as many more to be purchased in 1915, this part of the work is important.

Meter Shops

Under the New York City charter, meters are furnished and set by property owners upon the direction of the department. Under present regulations the department cannot require meters to be set except where water is used for business purposes. The meter rate is 10 cents per 100 cubic feet, irrespective of quantity used. This rate is approximately double the average income per million gallons delivered into the mains. It is therefore to be expected, as the frontage rate is in general materially less than meter rates, that meters will not be set except upon the order of the department. There are approximately 90,000 meters in use in the city. The charter further requires that all meters shall be of a type and sold at a price approved by the Board of Aldermen, upon recommendation of the commissioner of the department. There are seventeen makes of meters approved, thus affording the consumer a wide range in choosing his meter.

Before meters are set they must be tested for accuracy at one of the department shops, no charge being made for such test. After being set they are subject to retest at such times as may be directed by the department. The department does not make any repairs to meters, but requires the plumber to remove the meter, attend to the repairs and deliver the meter to the meter shop for test and certification. These meter shops are equipped with modern appliances, the installation at the 21th Street shop, Manhattan, where the majority of meters are tested, being shown by photograph, Plate No. 5. Large meters, above 2 inches in diameter, are frequently tested on the premises without moving same, by the installation of a test tee on the delivery line just beyond the meter and the use of a portable test meter which is attached by the inspector to the test-tee outlet. Where a large meter is found to be registering incorrectly the same may be repaired either in place or removed for repairs, at the option of the owner. The number of meters tested annually by each shop is as follows:

Manhattan	{ Premises	2547
	{ Shop	18196*
Bronx	{ Premises	738
	{ Shop	2177

* Includes meters sent from Queens and Richmond.



Brooklyn	{ Premises.....	2039
	{ Shop.....	6803
Queens.....	{ Premises.....	38
	{ Shop.....	—
Richmond.....	{ Premises.....	35
	{ Shop.....	—

The force employed in the Manhattan shop, where the largest amount of work is done, is as follows:

1 Inspector.....	\$1500
2 Inspectors.....	1100
1 Clerk.....	900
1 Stenographer.....	1050
1 Plumber.....	5.50 a day
1 Machinist's Helper.....	3.00 a day
5 Laborers.....	2.50 a day

TRANSPORTATION

Until approximately 1913, all transportation was by horse-drawn vehicles, city owned horses and vehicles being used in the boroughs of Brooklyn and Richmond and hired horses and vehicles in the other three boroughs. This difference resulted from continuation of practices followed before consolidation in 1898, there being no local transportation conditions which warranted a different system in one borough as compared with another.

The development of the automobile has resulted in a change in policy and light auto runabouts, with small wagon bodies, are used for the foremen, tappers and for light material, while auto trucks are being substituted for the horse-drawn trucks. The horse-drawn and motor-driven types are illustrated in photograph, Plate 6. It is estimated that the cost of transportation by horse-drawn and by motor-driven vehicles is approximately the same, based on mileage. The load transported, however, is mainly labor, and therefore the saving in time should be multiplied by the number of men transported, which is usually six to each gang. The main advantage in the use of motor vehicles is in the reduction in time in responding to emergency calls, and the resultant reduction in damage caused by breaks in large mains, and the much more efficient supervision by the foremen, where automobiles are available.

The department records on automobile service show the following



cost per mile for runabouts, touring cars and trucks, exclusive of the cost of driving:

Runabouts.....	4.6 cents per mile
Touring cars.....	7.7 cents per mile
Trucks.....	6.3 cents per mile

The touring cars are used by the superintendent and assistant engineers in charge of maintenance work.

The department has one three-horse truck, which has sufficient carrying capacity to handle any pipe or valve that might be required for repair or extension work, and it is proposed to continue this truck in use for emergencies even though automobiles may be substituted for all other transportation.

METHOD OF REPORTING REPAIRS REQUIRED

When a complaint is received at a repair company's headquarters, entry is made in a blotter kept for the purpose and the complaint is transmitted by telephone to the borough office. Here a complaint slip is made out in triplicate, two copies being forwarded to the repair company's headquarters, the third being retained as an office record. If a complaint is received directly at the borough office, a similar complaint slip is made out and forwarded to the repair company. The form of slip used is reproduced on plate No. 7. Each complaint is given a job number and all time and material consumed is charged to that job. When the complaint has been attended to, the clerk at the yard notes the action taken on the complaint slip and the duplicate is returned to the borough office. The record of material and time charged to the job is sent to the division of costs and statistics, which records all departmental expenditures.

Immediate action on complaints of an urgent character is taken by the foreman in charge of the repair company, the regular complaint slip being later forwarded to headquarters.

In the borough office there is a street map, mounted on soft wood, and pins with varicolored heads are daily placed at the locations of the different complaints. The assignments of gangs to jobs for the following day are also shown on this map; so that it can be determined at a glance the number and kind of complaints that have not yet been attended to, as well as the location of each gang.

CITY OF NEW YORK
DEPARTMENT OF WATER SUPPLY, GAS AND ELECTRICITY
BUREAU OF WATER SUPPLY

ORDER No. COMPANY No.

Com. No.	Ch. Eng. No.	Page No.
----------	--------------	----------

Received 191 , M., from
Sent on 191 , M., to Foreman of Repair Company
Assigned on 191 , M., to

Location

Complaint

REPORT

.....
Foreman.

PLATE 7—COMPLAINT SLIP

For the high pressure fire system, the procedure provides for notification of the fire department of all changes which affect that part of the system. If, for any cause, a hydrant cannot be utilized, a chain is attached thereto, carrying a metal tag on which are inscribed the words "Out of Order."

In general, the repair work is kept up so that routine repairs are made within two or three days from the receipt of complaint and emergency repairs are, of course, attended to immediately.

Taps

The department furnishes and places all taps and connections to city mains, the taps including wet connection sleeves and valves up to 20 inches by 24 inches being manufactured under departmental designs and specifications. Application for the tap is presented by a licensed plumber, and the size of tap granted is based upon the number of square feet of floor area in the building, the general standard being shown in the following schedule:

The area of one $\frac{1}{2}$ -inch tap shall be credited for the first 7500 square feet of floor area, one $\frac{3}{4}$ -inch for the first 15,000 square feet and above 15,000 square feet one $\frac{1}{2}$ -inch tap for every 10,000 square feet of floor space thus computed (or an equivalent combination of larger taps) viz:

Up to 7,500 square feet.....	1- $\frac{1}{2}$ -inch tap
7,500 to 15,000 square feet.....	1- $\frac{3}{4}$ -inch tap
15,000 to 20,000 square feet.....	2- $\frac{1}{2}$ -inch taps
20,000 to 30,000 square feet.....	3- $\frac{1}{2}$ -inch taps (or 2- $\frac{3}{4}$ -inch taps)
30,000 to 40,000 square feet.....	4- $\frac{1}{2}$ -inch taps (or 3- $\frac{3}{4}$ -inch taps)
40,000 to 50,000 square feet, etc.....	5- $\frac{1}{2}$ -inch taps (or 2-1-inch taps)

Where the occupancy of a building will require an unusual volume of water, the size of tap granted is in accordance with the probable demand. This system of floor area as a basis for determining the size of tap has been in use for the past three years and has given general satisfaction. Prior to its adoption, there was no standard by which to judge the size of tap to be allowed and there was, naturally, resultant dissatisfaction and charges of favoritism. After the size of tap has been determined, the excavation is made by the plumber, who notifies the department that the opening will be ready for the tapper on a given date and hour. The tapper is furnished with a

card authorizing him to insert a given sized tap and he returns this card with endorsement showing the size of tap inserted and the location of same. This information is then transferred to a tap card for filing, illustrated on Plate No. 8.

The department charges the property owner a fixed price for each size of tap, the present schedule being as follows:

CHARGES FOR WET CONNECTIONS		
Connection	Pipe Inches	Rate
2 inch.....	6	\$23.95
	8	25.45
	12	34.70
	16	40.45
	20	48.20
4 inch.....	6	27.50
	8	30.20
	12	38.15
	16	43.90
	20	51.65
6 inch.....	8	36.55
	12	45.95
	16	54.70
	20	59.95
8 inch.....	12	55.00
	16	66.75
	20	71.25
CHARGES FOR TAPS		
Size		Rate
1/4-inch.....		\$4.50
1/2-inch.....		5.00
1-inch.....		6.00
2-inch.....		15.00

All house services up to and including two inches in diameter are required to be of lead from the tap to the property line. The tap and service is inspected by an employee of the Bureau of Water Register, and the charge for water dates from the approval of the service and the turning on of the corporation cock. This cock is buried in the street and a curb cock set at the curb line.

Shutting Off Leaky Service

When notice of a leak is received effort is made by examination of the surface and use of the aquaphone to determine whether the

leak is on a service or the city main. As the services are owned by the property holder, he is notified to make repairs, if the leak is probably on his service. If its location is uncertain, the department gang digs up the main and continues excavation until the leak is found. If the leak is finally found on the city main it is repaired by the city force. If the leak is on a private service, the corporation cock is shut off and the repair work is turned over to the plumber representing the property owner. The department formerly billed the property owner for all excavations necessary to locate the leak. This procedure resulted at times in a severe

BLOCK	LOT	TAP OR PLUG PERMIT NO.	NO. IN SERIES	CARD NO.	118-13-25,000 (X)
					191
LOCATION OF PREMISES					STREET AVENUE
SIDE FT OF					STREET AVENUE
BUILDING	STORIES	FT. FRONT		FT. DEEP	
SIZE OF TAP	SIZE OF PLUG		ON A	INCH MAIN	
LOCATION	FT.	OF	BUILDING LINE OF NO.		
		AND	FT. FROM	CURB LINE	
SET	191	BY	TAPPER		
PLUMBER					

DISTRIBUTION DIV., FORM NO. 11—TAP RECORD CARD—DEPT. OF W. & C. & E. THE CITY OF NEW YORK

PLATE 8. RECORD TAP CARD

burden being placed upon the property owner, as where the sub-surface conditions were favorable, such as in a rock filled street, the leaking water might run for several hundred feet before it appeared at the surface. Numerous openings had to be made before the leak was discovered, and bills of several hundred dollars were not uncommon. Now the department charges only for the excavation which finally locates the leak, believing that the city should carry the extra charge as an insurance against any one property owner being heavily penalized, due to no fault of his own.

While curb cocks are installed, they are not of material use in locating leaks on services, as such leaks are usually between the main and the curb cock.

To insure payment for work done by the department, the plumber is called on to assume responsibility for the pavement disturbed and excavation made before the water is again turned on.

Pressure in Premises

New York City has, in general, a low pressure, the average in Manhattan and The Bronx being about 30 pounds, Brooklyn and Queens have approximately 35 to 40 pounds, while Richmond varies from over 100 pounds down to 20 pounds or less.

Many Manhattan and Bronx premises have tanks or house pumps, or both, but even with such auxiliaries in use the complaints of lack of pressure are quite frequent. Such complaints are turned over to an inspector who takes the pressure at the nearest hydrant, in the basement and on each floor, with and without a faucet flowing, and notes the size of the supply pipe from the main and the size of each riser and number of floors supplied by each. After the data obtained has been studied, the owner is notified of the conditions found, the probable cause of lack of pressure, and what action is necessary to remedy the conditions complained of.

Hydrant Repairs During Freezing Weather

The fire department force make continual inspections of hydrants during the winter months and report to the repair company headquarters hydrants that are frozen or in danger of freezing. These are then examined by the department force and the waste drip cleared and hydrant drained or else pumped out. Salt is placed in hydrants which leak slightly and do not drain properly. Experiments with the use of glycerine, alcohol, and carbide of lime as substitutes for salt are being made, but there is not sufficient data available on which to draw conclusions. Hydrants that are frozen are thawed out by the fire department, using the standard steamer, and by the water department, using a special portable boiler.

Operation of Valves

With about 60,000 valves in the system, it is difficult to operate the valves frequently enough to keep all valves in good condition. The department plans to operate and oil every valve once a year,

but so far has been able to keep up to this schedule for the large valves only, i.e., larger than 20 inches in diameter. With New York City water if valves are operated once each year they are kept in good general condition ready for operation at any time. It has recently been the practice to place metal pans over the gears to protect them from dirt. The boundaries of services are usually formed by closing valves, thus creating dead ends. Sediment collects in such dead ends and can only be removed by partially opening the valve and blowing off the sediment laden water through the adjoining hydrants. Special gangs are operating continuously on this work, the mains being blown out at intervals of from two weeks to several months, the time depending upon the rapidity with which sediment forms in objectionable quantities.

Response to Fire Alarms

The water department is responsible for the adequacy of the supply for fire extinguishment. Fire alarm gongs are located in all repair company headquarters, and a repair company gang responds to all two alarm fires in the low or domestic pressure districts. To all alarms in the high pressure fire service district, a special repair gang responds. On arriving at the fire the driver gets in touch with his headquarters so the gang can be located, and the men are held to act in case of emergency, such as lack of water, which might be relieved by opening adjacent district boundary gates. The foreman notes the location and number of engines, water pressure, etc.

Assignment of Assistant Engineer for Night and Holiday Duty

On the theory that men familiar with the water supply system and competent to act in emergencies should always be available, assignments are made so that two engineers, one for Manhattan and The Bronx, and one for Brooklyn, are always in reach of the telephone from the time the office closes until it is again opened. The city furnishes telephones in the homes of these men, but they do not receive any added compensation due to such additional duty. These men are called out for three or four alarm fires, as well as in emergencies resulting from any cause. They take charge until they are relieved by a higher official.

Controlling Pressures in Mains

Recording pressure gauges are located in the various repair headquarters and pumping stations, and also in some sixty fire company engine houses scattered throughout the city. These gauge charts show if there has been any unusual pressure changes and studies can then be made to determine cause and remedy.

The pressure in the Brooklyn low pressure system and the First Ward, Queens, is controlled by the operation, day and night, of headgates at the reservoir. If the pressure is normally in the day time between 35 and 40 pounds, it will rise above 45 pounds at night when such increase in pressure is useless. The pressure is, therefore, kept high from 5 a.m. to 11 a.m. From then until midnight it is kept about 5 pounds lower than during the morning, and at midnight it is further lowered about 6 pounds and kept at the low point until five in the morning, when the gates are again opened. With four 48-inch and two 36-inch mains feeding the service from the reservoir through six 36-inch valves, it is found necessary to have all valves opened from 12 inches to 18 inches in the morning, there being no effect if the valves are opened more than 18 inches. During the early morning hours three of these valves will be shut, two opened about 4 inches, and one, on a main that feeds a service pumping station, about 12 inches. Pressures are telephoned to the reservoir every hour and more frequently, if required, and men are on hand to immediately open valves if required. If a three alarm fire is recorded the valves are immediately opened, about ten minutes being required to give full pressure.

This system has been in use for nearly ten years, and no trouble has been experienced. The control of the pressures reduces the consumption by over five million gallons daily, or about five per cent of the total supply to this service. When all the water is pumped and difficult to obtain, this saving in water is material and is worth financially between \$100 and \$200 per day.

Measurements of Flow in Mains and from Hydrants

In studying trunk main capacity, the distribution of the flow is an important factor in determining whether existing mains are being utilized to full capacity, and also whether new mains are needed. Pitometer surveys are being made from time to time for this pur-

pose, three parties being continuously employed on this and similar work, the department owning 15 instruments. Measurements of flow are also undertaken to determine leaks outside of premises and as a result of such work during the past four years, i.e., from 1910 to date, leaks in mains and services have been located and stopped, amounting to 33 m.g.d. An interesting leak that was found by such measurements is shown on Plate No. 9. This was considered by the local inhabitants to be a spring which yielded water of a superior quality to the city water, and they were much surprised when the leak was discovered and the spring ceased to flow. The volume of water lost through fixture leakage is determined by the pitometer measurements, flows being recorded into districts before and after water waste prevention inspections have been made. The adequacy of the distribution system to deliver an ample supply for fire extinguishment is determined by testing the flow from hydrants, usually using a group of six and noting the drop in pressure and the discharge from each hydrant. Pitot nozzle gauges are used for this purpose, the force employed being the regular pitometer survey force.

Checking Waste in Building

Waste of water from fixtures within buildings has always been one of the problems that water works engineers and superintendents have had to contend with, and no satisfactory answer except metering has been found. Where metering is not permitted some other means must be adopted if the consumption per capita is to be kept within what is generally considered reasonable limits.

The consumption in Manhattan and The Bronx in 1910 was 331 m.g.d. with an estimated population of 2,762,500, making the per capita consumption 120 gallons daily. For the twelve months from July 1, 1911, to July 1, 1912, the consumption was 291 m.g.d., which, with an estimated population of 2,838,500 in 1911 would give a per capita consumption of 103 gallons daily. For Brooklyn, with a consumption of 155 m.g.d. and a population of 1,685,000 there was a per capita consumption of 92 for 1911, which was 5 gallons less than that recorded for the preceding year. In 1913 the consumption was 140 m.g.d. with a population of 1,791,100, giving a resultant per capita consumption of 78 gallons daily.

The reduction in consumption has been accomplished by water waste prevention inspection and by the stoppage of leaks in the



distribution mains and service pipes outside of buildings. It has already been stated that the total amount of leakage outside of buildings discovered and stopped during the past five years has amounted to about 33 m.g.d. The main reduction in consumption has therefore resulted from the water waste prevention work. The general procedure followed in this work is as follows:

Printed notices are delivered on the premises, calling attention to the necessity of preventing waste of water. This is followed by a house to house canvass, all fixtures being examined by an inspector. If any leaks are found the inspector leaves a notice of such leaks, the notice calling for repairs to be made within three days. A duplicate of this notice is mailed to the premises from the department office. A re-inspection is made after three or more days and if all leaks have not been repaired a fine of \$2 per premise is imposed. This fine is repeated if later inspection shows that the necessary repairs have not been attended to.

Before the inspectors go into any district, pitometer measurements are taken on mains which can feed said district, valves being temporarily closed to fix the boundaries. After the inspection is completed and the leaks stopped, the flow into the district is again measured and the leakage stopped computed.

Two extensive inspections have been made during the past four years, one in 1911 in Manhattan where the maximum leakage stopped in a five months' campaign was estimated to be 71 m.g.d., of which 21 m.g.d. is attributed to the house to house inspection and the other in 1912-1913 in Brooklyn, where it was estimated 30 m.g.d. was saved as a maximum. The inspectors employed in the first investigation reached a maximum of 114, while the total number of inspector days expended in inspecting and re-inspecting buildings and locating 197,000 leaks was 11,600 days. Each inspector received at the rate of \$1100 per annum and pitometer gaugings of flow into districts inspected cost about 35 percent of the inspection cost. The fines imposed just offset, however, the cost of these gaugings. The net cost of saving the water, assuming that all the leakage stopped would eventually reappear in two years time (experience shows that the actual time is longer) was about \$7.70 per m.g.

In Brooklyn in ten months, with nearly forty inspectors and 8800 inspector days, the net cost of saving the water was estimated at \$3 per m.g. using the same basis of computation as for Manhattan.

The maximum daily reduction in consumption per inspector employed is estimated at 900,000 gallons. The yearly reduction in annual expenditures resulting directly from this checking of leakage is estimated at \$400,000, while the total cost was about \$36,000, and the net cost, allowing for fines imposed, less than \$30,000.

The limited data available indicates that after six months' work the inspector is stopping leakage at about the same rate as the leakage previously stopped is reappearing. The work of inspection is under the Bureau of Water Register, but the outlining of the water waste prevention campaigns has been done by the Bureau of Water Supply.

RECORD MAPS OF DISTRIBUTION SYSTEM

For general use as wall maps and for the use of foremen and others in the field, tracings to a scale of 400 feet to the inch have been prepared, showing by symbol size of mains, connections, valves, hydrants, blowoffs, etc. Street lines are omitted except in outlying sections, as the mains indicate the streets and the additional lines are confusing. These maps are kept up to date and prints in the repair companies' headquarters are corrected each month as far as practicable. The boundaries of services are shown by colors.

Atlases to scales of 100 feet to an inch and 160 feet to an inch have been tried to record actual locations of mains, valves, hydrants and appurtenances, with depth of cover, when laid, etc. These have not been a success and it is considered that drawings to a scale of 40 feet to an inch will be more suitable with a scale of 20 feet to an inch being used where there are very complicated intersections. On the large sized scales can be shown location of taps as well as other details.

For the high pressure fire system each hydrant is numbered and maps to a scale of 300 feet to an inch are used for general maps, with the same sized scales for the detailed maps.

All the work of collecting, transporting, pumping and distributing the water supply for Greater New York is under Mr. Merritt H. Smith, Chief Engineer of the Bureau of Water Supply. The writer as Deputy Chief Engineer has come in close touch with the maintenance and operating problems and has found these studies most interesting. A more general statement of practice by the various water departments of our cities would be helpful in developing sound procedure in this branch of water supply.

DISCUSSION

MR. D. W. FRENCH: Will Mr. Brush kindly state whether should a break occur in the pipe system during a period of fire, resulting in a general reduction of pressure in the high pressure system, the department have any means of controlling the gates to shut off the damaged part of the pipe system, electrically from some central station, or if the gates would have to be operated by hand.

MR. WILLIAM W. BRUSH: In the domestic system, New York City does not have any hydraulically or electrically operated valves which may be opened from a distant control point to permit delivery of the supply from a higher level district into a lower level district. The boundaries of the different services are created by closing valves, and in case of an unusual demand, created by a break or other cause, one or more of these boundary valves are opened by the repair gang. In general, the distribution system is so proportioned that there is little need of delivering water from a higher to a lower level, although ten years or more ago this was necessary rather frequently in cases of large fires located near boundaries of services.

In the High Pressure Fire Service system there are electrically operated valves controlled from the pumping stations and used to separate the system into two parts, said valves being closed in case of a break. In the newer parts of the system alternate streets are on one system with intermediate streets on the other system, thus materially reducing the danger of the whole system becoming inoperative throughout any district, due to break in the mains or appurtenances.

JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

The Association is not responsible, as a body, for the facts and opinions advanced in any of the papers or discussions published in its proceedings.

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No. 2

MINUTES OF PROCEEDINGS THIRTY-FIFTH ANNUAL CONVENTION AMERICAN WATER WORKS ASSOCIATION

The Thirty-fifth Annual Convention of the American Water Works Association was held at the Hotel Gibson, Cincinnati, Ohio, on May 10, 11, 12, 13 and 14, 1915.

The following local committees had charge of the arrangements for the reception of members and visitors and ladies, and their entertainment during their stay in Cincinnati:

LOCAL COMMITTEES

HONORARY COMMITTEE

Hon. Frederick S. Spiegel, Mayor	
Hon. Philip Fosdick, Director Public Service	Hon. John R. Holmes, Director of Public Safety

GENERAL COMMITTEE OF ARRANGEMENTS

John W. Hill, Chairman	
F. C. Bitgood, Vice-Chairman	S. G. Pollard, Secretary
William B. Melish	E. B. Amole
August Herrmann	J. A. Hiller
Charles H. Anderson	Gustav Jarecki
Dawson Blackmore	Henry C. Hill
Thomas Ford	J. W. Ellms
James E. Brady	J. J. Conway
Carl Dehoney	H. Resinberg, Newport, Ky.
George W. Cleveland	J. Mason Howk, Covington, Ky.
Royal Mattice	R. P. Bricker, Shelby, Ohio

Frank S. Krug

CITIZENS' ENTERTAINMENT COMMITTEE

William B. Melish, Chairman
 S. W. Coffman, Treasurer Carl Dehoney, Secretary

FINANCE COMMITTEE

George W. Cleveland, Chairman
 E. B. Amole G. W. Galbraith
 F. C. Bitgood John W. Hill
 Dawson Blackmore Gustav Jarecki
 Philip Fosdick William B. Melish
 Maurice J. Freiberg Royal Mattice
 Howard Wurlitzer

FIRST SESSION—TUESDAY MORNING, MAY 11, 1915

The session was called to order by Mr. John W. Hill, Chairman of the General Committee of Arrangements, who referred to the fact that Cincinnati was now entertaining the Association for the second time in its history, the first Convention having been held in the old Gibson House in 1884, when he joined the Association, Mr. Hill being now the oldest living member in the city of Cincinnati.

Mr. Hill then introduced Hon. Frederick S. Spiegel, Mayor of Cincinnati, who delivered an address of welcome in behalf of the city.

ADDRESS OF WELCOME—HON. FREDERICK S. SPIEGEL,
MAYOR OF CINCINNATI

Mr. Chairman and Members of the American Water Works Association: This is your thirty-fifth annual meeting. I want to assure you that we are proud, that I am proud as the official representative of our city of Cincinnati, to have you with us. Conventions of the kind that you are having in our city during this week are always welcome. We have had many such, but it is an especially great pleasure to welcome you men who are not only men of scientific training, but every one of you is endeavoring in your particular field to create a higher standard and bring to the utmost perfection that which has become an absolute necessity to all of our people, the water which we drink. Every one of you in his particular field is doing what all the rest of us are doing in our particular fields, whether we are engaged as professional men in the practice of law, medicine, or divinity. All of us are endeavoring to achieve what is best in our chosen fields of activity.

The fact that you are here the second time proves to me that you have a feeling of attraction for our city that has been known for years and years as the Queen City of the West.

Our city is so fortunate as to be located midway between the south and the north. We therefore partake of the qualities of both sections of our country. The hospitality of the south is ours, and the thrift and the activity of the north. We are glad to extend that hospitality to those who come to us, and we sympathize with those who are engaged in callings that call for hard work and hard study.

Cincinnati has become famous for institutions in which you are particularly interested. I think that I may safely say that we surpass in some of these perhaps every city in this country of ours, this great United States of America.

Our water works as they are at present have among other benefits conferred upon us reduced the death-rate from diseases and particularly that disease which is due to insanitary water supply, perhaps twenty-five per cent. We are delivering sixty million gallons of water a day for the use of our citizens, pumped out of the Ohio River; and every one of you men who know all about water and its qualities, know that water pumped out of a river without treatment is unfit to drink.

Cincinnati has taxed itself in order to develop possibly the finest water works in our country. Our filtration plant, our high-pressure service for bringing the water into every part of our city, our machinery and all of the equipment of our water works plant, are the pride of our city.

After we had completed the water works our city proceeded in other lines of progress. We established an educational system which is not merely academic, which does not merely teach that which is known as an academic course, but our common schools with our great municipal university at their head, also include in their educational training scientific training. It is the aim of our educational system to train our youth in everything that will fit them for an active career of usefulness in their future lives.

Only three weeks ago, or possibly four weeks, I took over as the representative of our city one of the greatest hospitals in these United States, comprising twenty-nine buildings, all fitted up and equipped with the most modern surgical and pathological equipment, in fact, everything necessary in the domain of healing disease.

This hospital will be open for you to inspect, and I hope that you will go through all of the buildings and see how admirably they are adapted for the purposes for which they are designed. I know that you will feel that we have a right to be proud of that general hospital.

We have here in Cincinnati a zoological garden where Hardenberg, when he comes to this country, leaves his animals. It is one of the finest gardens probably in the United States. We have an art museum to which one of the magnificent women of our city who is famed for her philanthropy and civic pride has given a Velasquez, purchased at a cost of \$200,000, and which is now the property of the city of Cincinnati.

Now that you are with us we want you to see this city of ours for yourselves, and after you have seen it, I am certain you will agree that it merits all that I have claimed for it.

The doors of our city are open to you and we welcome you here. I have a great big key in my private office at the City Hall, so big that I could not bring it down unless I got two or three people to come along with me and help carry it. It is very heavy. But you need no key to open to you our doors. There is nothing too good for you in Cincinnati. Enjoy our hospitality to the full, and also all of your ladies, your wives, your sisters, and your sweethearts enjoy it with you. It is our desire and our wish that you have everything that we can offer you and all you need do is to send word to the City Hall if there is anything you need, and the Mayor will respond. I thank you. (Applause.)

CHAIRMAN JOHN W. HILL: *Mr. Mayor, Mr. President and Gentlemen*—Some philosopher has said that he indeed is a benefactor who makes two blades of grass grow where one grew before.

It is now my pleasure to introduce to you one of the best known men in the United States, undoubtedly in this country, and perhaps abroad. When I tell you of some of his exploits, although you may never have heard his name spoken in your own communities or mentioned in the public press; you may never have known him or at least many of you have not until this time, you will now recognize in the next speaker a man who has done more perhaps for the benefit of mankind than any man in or out of Cincinnati. I speak advisedly as an engineer, and you know that engineers are bound to be reasonably correct in their estimates of people as well as other things.

He was a member of the legislature when the water works law under which we built our magnificent system of water works that

Judge Spiegel told you about was enacted; and he worked for that in season and out of season. I know something about that, because I assisted in that matter myself at that time. This gentleman was earnest in advocating this measure.

With your permission, I will now introduce Hon. Philip Fosdick, Director of Public Service of Cincinnati. (Applause.)

ADDRESS BY HON. PHILIP FOSDICK, DIRECTOR PUBLIC SERVICE, CINCINNATI

Mr. Hill, Mr. Mayor, Mr. President and Gentlemen—I am going to give you a very brief synopsis by way of a comparison of our water works today with what they were twenty years ago. I will make it very brief.

On March 31, 1817, the first franchise was granted for a water works in Cincinnati. On July 3, 1821, the first water was pumped. On June 25, 1839, the then existing water works became the property of the city of Cincinnati. On April 24, 1896, the new water works act was passed by the General Assembly of Ohio. On February 2, 1897, the Supreme Court of Ohio sustained the validity of the Act. On June 1, 1897, preliminary surveys were begun. On May 15, 1897, construction was begun. On November 1, 1907, the entire city was supplied with filtered water from the new works. On July 1, 1909, the operation of the new works was turned over to the Department of Public Service. Improvements costing two million dollars have been added since the completion of the new works.

There is shown below a comparison of the old and new works in certain particulars, as follows:

	<i>Old</i>	<i>New</i>
Quality of water.....	Muddy, disease laden	Clear, pure
Quantity of water.....	Barely sufficient	Enough with a large reserve capacity
Typhoid fever cases.....	Average of four years, 1396	Average of four years, 205
Typhoid fever deaths.....	Average of four years, 202	Average of four years, 29
Population supplied.....	Year 1906—346,000	Year 1914—406,000
Average daily consumption.....	Year 1906—40,000,000	Year 1914—51,000,000
Pumping station.....	7	3
Number of employees.....	500	370
Cost of pumpage.....	\$487,000.00	\$255,000.00
Total cost of operation.....	\$866,000.00	\$509,000.00
Sinking fund and interest.....	\$339,000.00	\$713,000.00
Miles of mains.....	482.0	712.0
Miles of mains greater than 12 inches in diameter.....	37.5	85.2
Number of service branches.....	42,765	57,613
Number of metered services.....	6,536	35,201

Your convention assembled here today certainly means much to Cincinnati and will add vitally to certain phases of our public service as it is utterly impossible for a serious conference among men such as you to be held without doing something for the public good.

It has taken me many years to learn the fact that any step of progress must necessarily be slow, because the slightest advancement over the old means a complete evolution of process and precedent.

We are all engaged upon a serious study to find out what is the best quality of material for street paving, and although we have been studying this question for centuries, we are still far from attaining our object. This is so, because as we study, conditions change, and our line of thought must necessarily be along strange paths. The automobile and the automobile truck, doubtless both in their infancy, bring up new questions, and no sooner have we arrived at what we think is a permanent conclusion, when lo and behold, the entire vehicular question is changed and our minds must shift to the new range.

It seems the distance round the world from the old pump and cistern to the gigantic machine that sends millions of gallons of water to municipal communities every day, and yet I would not be surprised that the future shall produce an equally large advance in the method of furnishing this necessity to human beings who will be grouped together in the cities of the future. The matter is further complicated by the fact that each city possesses characteristics of its own, and each one requires in a measure a different treatment. Take for example the two largest cities in Ohio, Cleveland and Cincinnati. The surface of Cleveland is flat. Cincinnati's topography is as varied as a mountain range, although of course on a smaller scale. The men at the head of the municipal departments here are compelled to overcome steep grades, attain great heights and build on hill sides.

Gentlemen, the Department of Public Service is at your disposal. We think we are progressing in our work in all departments and believe that the people who live in cities are being taken care of by municipalities in a manner our predecessors never dared even to dream of. I am certain that none of the elementary problems of municipal life have been better solved than that of the water supply and the water distribution, and it is to people such as you that we are indebted.

Again, I take the greatest pleasure in welcoming you to our very beautiful city. We have a really beautiful city. Take our park-

way; it is not large, but what there is of it I think is as beautiful as in any city in Europe or America.

I do not want any of you to forget to look at that beautiful view up and down the Ohio River that you can get from Eden Park, or you can look across to the hills of Kentucky. Then there are numerous parks. There is Devou Park over in the state of Ohio, within ten minutes ride of this hotel, which is very beautiful. We have also Ault Park, presented to us by Mr. Ault, from which you get beautiful views of the Miami River.

I have taken up a great deal of your time, and I want to thank you for your attention, and again welcome you to our city. (Applause.)

RESPONSE TO ADDRESSES OF WELCOME

BY PRESIDENT GEORGE G. EARL, NEW ORLEANS, LA.

Gentlemen of the Local Committee, and Gentlemen of the Convention:
We certainly all deeply appreciate the kindly words of welcome that have been given to us. We feel certain that we are going to have here in this city of Cincinnati a particularly successful convention.

The Association is to be congratulated upon the good attendance, and also upon the energy and progressiveness of this city of Cincinnati of which the Mayor has spoken to some extent.

I feel that perhaps the water works fraternity appreciate even more deeply than I do myself, if that were possible, the position that Cincinnati and Louisville also took in the matter of the investigation when water purification was the problem which was presented to them for their particularly difficult rivers. I know that that problem had been seriously before the city which I represent. I know that when it was proposed there one contractor offered to filter some river water, making all kinds of guarantees, and that the filter company was bold enough to give those guarantees and attempt to filter Mississippi River water without preliminary treatment. I know that that company spent a great amount of money in trying to do that, but found that they had undertaken an absolute impossibility. They could not do it, and the filter company was seriously hurt by the attempt. The city was hurt, and the private company who went into a contract of that kind were hurt, and they were convinced that the Ohio water could not be filtered; and they were betrayed into an attitude which ultimately cost them their franchise.

When that same condition was presented to Louisville, and again to Cincinnati, instead of going blindly into a contract of that kind they insisted upon having some demonstration first, with the result that small amounts relatively of money spent in careful preliminary investigation blazed the trail for future water purification work along those lines, so that when that problem came to me I could look back to the report and studies which Louisville and Cincinnati had worked out and perfected, and could recommend that there was safety and certainty along those lines. It is for that reason, especially, that I feel that the water works fraternity, and most of all those of us who have problems similar to that of Cincinnati and Louisville, feel particularly grateful to the city of Cincinnati.

CHAIRMAN JOHN W. HILL: *Mr. President and Members of the Convention*, I would like to read you the following telegram from Captain Horace Tarr. I think that every one in the Association knows the Captain well. We expected him to be here today. His telegram is as follows:

PHILADELPHIA, May 10, 1915.

John W. Hill,
First National Bank Bldg.,
Cincinnati, Ohio.

Kindly say to my friends that owing to a death in my family today it is impossible for me to be at the convention, which I regret exceedingly, as I should have taken great pride in showing them the California engines. However, I trust to you to do the station honors. With fond regards to all my old associates, I am

Yours H. G. H. TARR.

The following invitation was read by the Secretary:

CINCINNATI, May 6, 1915.

J. M. Diven, Esq.
Secretary-Editor,
American Water Works Association.

Dear Sir: On behalf of the Cincinnati Section of the American Chemical Society, permit me to extend a hearty welcome to our city, and, at the same time to extend an invitation to attend our regular meeting on the evening of May 12, at 8 p.m. at the University of Cincinnati. On this occasion Dr. G. B. Heckel, Secretary of the Educational Bureau of the Paint Manufacturing Association of the United States, will be speaker of the evening. Our interests are mutual and I am sure a profitable and social evening is in store.

Respectfully,
CHAS. T. P. FENNEL, *Pres't,*
Cincinnati Section,
American Chemical Society.

ADDRESS BY PRESIDENT EARL

Gentlemen: The making of a presidential address to a great national association is an honor which I never expected to attain, and, to speak truthfully, which I had never desired to attain. It is an honor, moreover, for which I do not feel myself to be properly equipped, and one which I undertake therefore with extreme reluctance.

It was with great regret that I had to forego attendance at the Philadelphia Convention last year, both because it was the first convention of this Association which I had missed since 1909, and because of early personal associations which make the city of Philadelphia particularly attractive to me.

Not having been with you last year, it is now incumbent upon me to express the deep appreciation of, and gratitude which I feel for, the honors that you have conferred upon me in maintaining my name on your official list since 1910, and especially in persisting, after the practice of official succession, which I have always opposed, was supposedly eliminated by the general ballot for nomination, in electing me as your President.

I feel doubly honored in that my name stood with two of your most active and highly regarded members in this ballot, either of whom, you must have known, could serve the Association's interests better than myself, and I am constrained to feel that both of these gentlemen were in large degree parties to the conspiracy which resulted in my election.

The kind expression of Mr. Hill at your last convention, in assuming the Vice-Presidency, as published in the June issue of the Association's *Journal*, was most graceful, and is in particular deeply appreciated.

My inability to attend the last convention, and the distance of my residence from the center of "distribution" of the society's activities, both constitute serious handicaps to the usefulness which the Association has a right to expect from its President. Fortunately, however, the Association has tried and tested men in its active executive positions, and men on its committees who give unstinted effort toward its welfare, and great ability to the solution of its problems, and from their reports, rather than from your President's address, you will gather the record of substantial progress which the year has shown.

In looking over the volumes of this Association's *Journal*, and journals of other associations as well, perhaps the most conspicuous thing is the scope of topics which present themselves as allied with and essential to the present day water works practice. A generation ago, an able man might specialize in water works and reasonably well cover the field; today, a rather modest water works outfit demands specialists in several lines to coöperate in its attainment and its maintenance and operation. And aside from the pleasant social intercourse, the greatest good of this Association lies in the lesson of the necessity of coöperation in any worthwhile accomplishment which it brings home to each of us. It is around this central idea of coöperation that I shall now speak, in its application not only to the individual water works plant, but also to this Association, to the whole water works interests, and to the interest of humanity itself.

Broadly speaking, nothing is worth while which does not advance the interests both of justice and of humanity, and any work undertaken which conforms with these objects should appeal to the people in whose interest it is undertaken. Tactful voicing of this appeal, with clear and candid statements rendered to the public, are essential to the promotion of that coöperation from this source without which no work can prosper.

Not long ago I had the pleasure of dining with the head of one of the country's greatest corporations, and, when the opportunity offered, I asked him what, in his experience, was the hardest vital thing to attain in his management of its affairs. His reply, without any hesitation, was "to keep everybody boosting, not to keep them boosting me, or to keep them boosting the corporation, that is easy, but to keep them boosting one another"—in other words, effectively, helpfully and unselfishly coöperating.

The very qualities of great personal ability and self-reliance, which render many men of inestimable value, tend in some degree to destroy in them the spirit of coöperation and tolerance which are, and always will be, essential to the teamwork, without which the highest success of great undertakings can never be attained, and without which, as their responsibilities grow, they will find themselves unable to progress as they might otherwise.

The organization which has a chief who cannot learn anything from or give any credit to his subordinates, and as a sequence, or even without this inciting cause, has subordinates who are working at cross purposes with their chief and with one another, is seriously

handicapped, not only in its actual work, but also in maintaining the public confidence and coöperation which a united front can maintain, and which is essential, not only to its well-being as an organization, but also to the well-being of the individuals composing it.

The great purpose which associations like the American Water Works Association are accomplishing is in obtaining a constantly wider and more effective coöperation in the diffusion of knowledge and the interchange of ideas looking to the improvement of the various factors which enter into the water works practice of today.

The more interested men, and the more trained men, and the more men who desire to broaden themselves in this field of usefulness, that can be induced to coöperate to these ends, the better will be the results.

Other more or less local water works associations hold meetings and publish valuable papers and reports which this Association could profit by, and these associations in turn themselves could profit equally by the papers and reports of this Association.

Very few water works officials can spare the time or money to attend several conventions each year, and relatively few can belong to two or three associations, and keep up with their papers and reports, and those who have special experiences or ideas of value cannot spare the time, or for one cause or another do not care to repeat substantially the same paper to two or three associations. And when it happens that standards have to be adopted, or any general movement is in progress looking to the interest of the whole water works fraternity, the multiplication of unaffiliated associations is a distinct cause of complication and delay.

Many of us belong to and take great pride in our membership in some of these associations, but holding to the conviction that the greatest good is to be obtained by the broadest possible coöperation, and being unable to attend more than one convention, we have to forego the pleasure and profit which we would have in meeting more of the membership of the other associations than attend the conventions of this Association, and therefore lose the opportunity which might otherwise exist of receiving from or imparting to these much that would be of mutual interest and helpfulness, while those of our members who are able to attend several conventions, and to do their full duty by presenting to two or more associations papers covering valuable contentions in water works matters, are performing a most arduous and unnecessary double duty.

There seems, therefore, to be every possible reason for the union of all of the water works associations of America, with as many local branches and branch conventions and headquarters as can be maintained, but with one national annual convention and one common publication of all papers covering new matter of general interest.

A splendid start in this direction has been made through the present very liberal conditions and regulations offered by this Association for such consolidations and two very desirable connections have already been consummated, with a third in prospect.

I believe that the best interests of all water works associations demand that this movement be continued and accelerated, and the advantages to be gained by all parties of a more prompt and effective coöperation from such consolidations would be so great as to warrant the highest effort and the greatest of mutual concessions. Fortunately, the relations between these various organizations have heretofore always been most pleasant.

A national water works association that included every existing organization and reached every water works in the country could do better work, and could through its larger membership make its work count for more in the obtaining of general public faith and coöperation in its standards and suggestions.

The progress which the physical side of water works problems has made, and is making, speaks loudly and truly of the unselfish coöperation which has always existed and still exists between the allied professions whose efforts are responsible for the advance which by its momentum must continue.

The end which lags and which should be given the best effort of your best minds, however, has reference more to the matter of water rates and accounts and to the means and relations which exist in the matter of connections from the main to the property line, and in the matter of the maintenance of such connection and of the meter which should exist on each connection.

The monumental work which the Committee on the Tabulation of Water Rates and Allied Comparative Data submitted to the Convention at Philadelphia reflects the greatest credit upon the persistence and industry of the Chairman and those members of the Committee who may have been able to coöperate with him in its preparation. It includes over 100 pages of comparative statistics, applying to over 300 cities, and has been prepared with the

greatest care with a view of assembling together an intelligible and comparable résumé of certain features of water works practice. The data include information as to water rates, distribution systems, electrolysis, metered services, source of supply, pumpage, treatment and consumption, public fire service, private fire service, private service lines, and while it represents information of the highest value, as a matter of reference so far as it goes, it tends mainly to emphasize the very wide divergence of practice, and the almost chaotic condition as to what may be considered the best practice in many of these matters.

When we examine in detail the annual reports of water works plants, all over the country, we find even more strongly marked this divergence of practice, and we find ourselves absolutely unable by comparative study of accounts to formulate any satisfactory comparison in almost any matter pertaining to them.

The divergence of conditions and interests, as between publicly and privately owned plants, is one cause of this trouble. The gradual growth of plants, and the cumulative effect and inherent inertia of outgrown conditions, and of accumulated mistakes, are in part responsible. The persistent survival of flat rates for water and illogical conditions as to payment or non-payment for fire protection, based on every conceivable measure of probable use or relative influence, are the main obstacles to any approach to better conditions, and the inherent and obvious inadaptability of existing meter rate schemes to deal fairly, as between different classes of consumers, is the real stumbling-block in the way of the universal introduction of meters and the general reconstruction of water and fire service rates.

The officials of many cities see the necessity of universal metering to save unnecessary expenditures in extensions and operation, but they do not see how they can curtail consumption and maintain the necessary revenue without resorting to some one of the numerous expedients which are variously used to create an unfair difference in favor of one or the other of their various classes of consumers, because in existing rates one or another class of consumer has been paying too little and will strenuously oppose an increase.

The Committee's tabulation shows a range of meter rates of from five to fifty cents per thousand gallons charged to small consumers, and from two to twenty cents per thousand gallons charged to large consumers; and even at fifty cents it is quite possible that some of

the small consumers are getting more service than they are paying for, and certain that others are getting very much less. Meantime, every flagrant overcharge of one class of consumer in one place is breeding discontent, and every flagrant undercharge of the same class of consumer in another place is encouraging that discontent, and the water works interests are being ground between the millstones of these discontents; and with the wide diversity of rates and of opinion as to the proper basis for rate making, as between different classes of consumers, including the tax payer, the ultimate fineness of the grinding of these millstones and the question of the availability of fuel to keep them turning, needs little comment.

It is fully recognized that existing laws, contracts, customs and conditions complicate every consideration of a rapid revolutionary change in any given case, and not only that each class of consumers whose pocket never would be touched will constitute an obstacle, but also that those who would be benefited will be suspicious and slow to recognize the benefit, and to lend their coöperation. For this reason, great educational work will be necessary, and the approach to better conditions will be slow.

The greatest opportunity for coöperation today, which is before the various water works associations, lies in the commanding position which a short, clear, comprehensible dedication of the general principles which should govern a proper division of the necessary total water revenue, as between the tax payer and the water rate payer, and as between the various rate payers, would hold; such a dedication could not bring all rates suddenly to the recommended basis, but it would tend to bring the coöperation of general public sentiment into play, and thereby cause all movements to be toward the general system recommended, and it would act as a buffer in the meantime for the company or city where some particular phase of its rate system is under fire, and really may be inequitable, to show exactly why such rate has to be charged, leaving the burden of defense of the too low charges which compose it, and which may be enjoyed by the small consumer, or the large consumer, or the tax payer as the case may be, to their beneficiary.

There have been many papers and discussions before this Association that bear upon various phases of this question, and there is a well established practice as to the determination of what con-

stitutes an efficient service, and as to how to arrive at a reasonable value. There is no great divergence of opinion as to what constitutes operation and maintenance expense, or fixed capital and depreciation charges, or a reasonable profit over and above these, and public service corporations nearly everywhere have to stand ready to show and defend their status in these respects, and are prepared with expert help to establish all of the things.

It is not, therefore, the question as to the total revenue which should be allowed, but rather the question as to how the payment of such revenue should be divided between the various classes of consumers, including the tax payer, which needs to be illuminated, regarding which, so long as the total profit is not reduced, the business departments of the water works fraternity will be in the strongest position if they lean toward a fair deal for every interest in its adjustment, leaving the parties who have the bills to pay to do a large part of the worrying.

The reports of your officers and of your standing and special committees are now to follow. Considerable time and study have been given to the preparation of these reports, and also of the various papers that are to be presented. In their discussion a great deal can be gained by an exchange of thought and experience, and I trust all will come forward and assist in the advancement of ideas for the solution of these many problems that confront the water works officials and superintendents.

Gentlemen, I thank you for your attention.

REPORT OF EXECUTIVE COMMITTEE

Your Executive Committee have received from members of the Association in the State of Iowa a formal request for the approval of this Association for the formation of a local section, to be known as the Iowa Section of the American Water Works Association; also a proposed constitution for the government of the Iowa Section when formed, and have approved both.

Your Executive Committee have also received an application in due form from twenty-four members of the Central States Water Works Association to form a local section, to include the following territory, viz.: Southern Michigan, Ohio, West Virginia, Kentucky and Pennsylvania west of and including McKean, Elk, Clearfield, Blair and Bedford Counties. Also presenting a proposed constitution for the government of the section when formed, both of which your committee approve.

In accordance with the recommendation of the Canvassing Board, appointed to canvass the vote for officers for the ensuing year, we recommend

the amendment to the constitution of the Association as suggested by the Canvassing Board, but with some modifications, making the amendment read as follows:

Substitute for the second paragraph of Section 3, Article VI, the following:

"The three members who shall have received the greatest number of nominating ballots for the office of President, the three members who shall have received the greatest number for Vice-President, the three members who shall have received the greatest number for Treasurer, and the six members who shall have received the greatest number for Trustee, shall thereby be placed in nomination; provided that no member shall be placed in nomination for more than one office; and provided further that no member shall be placed upon the ballot who shall have received less than twenty-five nominating ballots, and if there be a tie vote among the number required to be placed in nomination, an additional number of names to cover such tie shall be placed in nomination; any member who shall be nominated for more than one office shall have his name placed upon the ballot for that office for which he shall have received the highest number of nominating ballots."

Your Executive Committee have, also, received another amendment to the constitution changing the form and manner of election, signed by the requisite number of members and accordingly submit the same for your consideration.

The required number of members have presented a petition for an amendment to Article VI, Section 5, and to Article VIII, Section 1, which is also submitted for your consideration.

Your Executive Committee recommend the election of Mr. John Caulfield, an old time member and regular attendant at all of the conventions of the Association, of which he is a past president, to honorary membership.

GEORGE G. EARL, *President*

ROBERT J. THOMAS

NICHOLAS S. HILL, JR.

H. E. KEELER

CHAS. R. HENDERSON

JAMES M. CAIRD

LEONARD METCALF

THEODORE A. LEISEN

EDWARD BARTOW

DOW R. GWINN

J. M. DIVEN, *Secretary*

REPORT OF CANVASSING BOARD

TROY, N. Y., May 5, 1915.

Mr. George G. Earl, *President*,
American Water Works Association,
New Orleans, La.

Dear Sir: Your Canvassing Board appointed to canvass the votes for officers of the American Water Works Association for the ensuing year report as follows:

Total number of votes cast for President 590, as follows:

Nicholas S. Hill, Jr	393	
Charles R. Henderson.....	50	
Allan W. Cuddeback.....	26	
Allen Hazen.....	121	
	—	590

Total number of votes cast for Vice-President 592, as follows:

Leonard Metcalf.....	358	
Edward Bartow.....	153	
Theodore A. Leisen.....	81	
	—	592

Total number of votes cast for Treasurer 587, as follows:

James M. Caird.....	401	
A. A. Reimer.....	38	
Rudolph Hering.....	84	
A. N. Talbot.....	54	
S. T. Powell.....	10	
	—	587

Total number of votes cast for Trustees 1113, as follows:

Carleton E. Davis.....	389	
C. H. Rust.....	247	
F. C. Jordan.....	203	
H. M. Ely.....	107	
W. S. Cramer.....	57	
F. A. Barbour.....	110	
	—	1113

We find that, under the provisions of the constitution, literally interpreted, one name might appear on the ballot for several offices; also that names are placed on the election ballot that receive very few nominating votes, in some cases only one. We therefore suggest the following amendment to the constitution:

ART. VI, SECTION 3: Second paragraph, write "two" for "three," first line; ditto, second line, ditto, fourth line. Write "four" for "six" fifth line, making the paragraph read:

"The two members who shall have received the greatest number of nominating ballots for the office of President, the two members who shall have received the greatest number for Vice-President, the two members who shall have received the greatest number for Treasurer, and the four members who shall have received the greatest number for Trustees, shall thereby be placed in nomination." Add the following: "A third member shall also be placed in nomination for election to each of the offices of President, Vice-President, or Treasurer, and two additional members shall be placed in nomination for election as Trustees, provided that each of them shall have received a number of nominating votes equal to at least twenty per cent of the number received by the member for whom the greatest number of nominating votes shall have been cast for the same office; provided, however, that no name shall appear on the

election ballot for more than one office. If there be a tie vote among the number required to be placed in nomination, an additional number of names to cover such ties shall be placed in nomination."

WM P. MASON

JAS. H. CALDWELL

J. M. DIVEN

Canvassing Board.

PRESIDENT EARL: Gentlemen, you have heard the announcement of the result of the ballot for election of officers for the ensuing year. The officers who received the necessary number of votes as therein stated for the respective offices to which they were nominated are declared duly elected.

AMENDMENTS TO CONSTITUTION

Secretary Diven read the following proposed amendment:

Amend Article VI by striking out all of Section 3 and substituting therefor the following:

SECTION 3: On the third day of each annual convention, or on a day to be designated by the Executive Committee, the Convention shall elect a Nominating Committee, whose duty it shall be to suggest nominations for the officers of the association for whom there shall be a letter ballot of the membership. Said Nominating Committee shall consist of five Active, Honorary or Corporate Members, representing the following territorial distribution of the membership, to wit:

(1) The New England States, (2) The Middle States, (3) The Southern States, (4) The Central States, (5) The remainder of the United States, and all territory outside of the United States. The nomination for members of the Nominating Committee shall be made on the floor of the convention, first by placing in nomination of an Active, Honorary or Corporate member to represent the above geographical subdivisions who may be selected by the Active, Honorary or Corporate members from said geographical subdivision in attendance at the convention, and if such nomination is not so made, a nominee, representing any geographical subdivision failing to so submit a name, shall be made from the floor of the convention. The member of such nominating committee whose membership in the Association is the oldest shall be Chairman.

The Nominating Committee, so elected by the convention, shall cause to be mailed to the membership, within six months after the convention at which they are elected, a list of the nominees for the respective offices of the Association, for which the constitution provides there shall be a letter ballot of the membership. Up to within three months of the time of holding the next annual convention, additional nominations may be made by request to the Secretary, signed by at least twenty-five Active, Honorary or Corporate

members, and upon the receipt of such request, the Secretary shall add such additional nominees to the final ballot to be prepared by him. The nominees of the Nominating Committee shall head such final ballot for each office, and any additional nominees for the respective offices shall be placed under the nominees of the Committee in alphabetical order.

Amend Article VI, Section 4, by striking out the words "Twenty-one days" in the second sentence of the first paragraph of said section, and substituting therefor, "two months," so that this paragraph shall then read as follows:

"SECTION 4. Election shall be by letter ballot. At least two months before the date of the annual meeting, a ticket shall be mailed to each member of the Association entitled to vote."

Submitted by the following members:

MORRIS R. SHERRERD
THOMAS F. HALPIN
ALEX MILNE
J. WALTER ACKERMAN
F. W. CAPPELIN
E. E. DAVIS

The Secretary also read the following amendment proposed as a substitute for the suggestion of the Canvassing Board and recommended for adoption by the Executive Committee:

The three members who shall have received the greatest number of nominating ballots for the office of President, the three members who shall have received the greatest number for Vice-President, the three members who shall have received the greatest number for Treasurer, and the six members who shall have received the greatest number for Trustee, shall thereby be placed in nomination; provided that no member shall be placed in nomination for more than one office; and provided further that no member shall be placed upon the ballot who shall have received less than twenty-five nominating ballots, and if there be a tie vote among the number required to be placed in nomination, an additional number of names to cover such tie shall be placed in nomination; any member who shall be nominated for more than one office shall have his name placed upon the ballot for that office for which he shall have received the highest number of nominating ballots.

PRESIDENT EARL: What is the pleasure of the Convention in regard to the amendments to the Constitution, of which there are practically two before the Convention? Do you wish to vote on them at this time, or lay them over for further consideration?

MR. ROBERT J. THOMAS: I move that that amendment to the Constitution recommended by the Executive Committee be adopted.
The motion was seconded.

MR. MORRIS R. SHERRERD: It hardly seems fair to me that such a motion as that should prevail without consideration on both sides by the members; therefore, I would like to say a word on the relative advantages and disadvantages, to my mind, of those two methods. The difficulty about the method of procedure adopted during the last year is to my mind a difficulty which will be continuous by the adoption of the amendment suggested by the Executive Committee; that difficulty is that it necessitates in order to get any large number of votes for any candidate so proposed that somebody shall jockey around among the membership and suggest a ticket.

The amendment proposed by the Executive Committee would also make it possible that there would be no nominees for Trustees, as only names which received twenty per cent of the total ballot are to be placed on the ticket, as I heard the reading of those suggested amendments.

THE SECRETARY: Not twenty per cent, but twenty-five members.

MR. SHERRERD: I understood it twenty per cent.

SECRETARY DIVEN: That was the recommendation of the Canvassing Board. The recommendation of the Executive Committee was twenty-five votes.

MR. SHERRERD: There might happen to be some dozen candidates who might receive the nomination of their local sections which would make it very confusing, although the final ballot represented the distribution among the states that the Constitution provides, namely, there shall not be more than one Trustee from any one state.

I believe that this Association made a mistake when it departed as far as the present Constitution departs from the interest which has always been taken at the Convention in the selection of its officers. That is one of the features of the convention which has always been interesting, and it is one also which allows the membership from different parts of the country to get their heads together and make suggestions as to what tickets or what officers would be best for the interests of this Association; and it was with the idea of getting somewhat back to the former method of procedure that the amend-

ment was requested to be considered by six of us who have presented it for your consideration. It is difficult when an amendment such as the one just presented is read to grasp its scope. If you will pardon me, I will try and outline briefly what is intended to be accomplished.

The geographical subdivisions suggested are five, and from the membership located in those five subdivisions, and from the membership in attendance at the Convention from each one of those five sub-divisions, there would be a suggestion of a nominee to place before the Convention for a member of the Nominating Committee.

The sub-divisions suggested are the New England States, Middle States, Southern States, the Central States, and the rest of the United States and the territory outside of the United States, which would make five subdivisions geographically of the membership.

Say on the evening before a meeting at which nominations were to be made the representatives in attendance at the Convention from New England would meet in some committee room, and decide among themselves who their representatives on the Nominating Committee should be. On the next day some one of that delegation would make the nomination on the floor of the Convention that Mr. Thomas, for instance, had been selected as a representative on the Nominating Committee from those of us who were in attendance, and then move his nomination and the Convention would vote on his name. Now in a similar way the Middle States would suggest, we will say, Mr. J. Waldo Smith, and his name would be before the Convention as a member of the Nominating Committee; and in the same way other representatives from the different territorial distributions would be placed before the Convention, five names in all; and if the Convention elected those gentlemen as the Nominating Committee they would be probably here at the Convention and they would represent a distribution of the membership, and they would represent the opinion of five gentlemen who knowing the needs of the Association from the different standpoints throughout the country would be able to name gentlemen for officers, and present within six months thereafter a ticket to be voted on which would be the consensus of opinion as distributed throughout the entire territory in which the membership is located; and it would give that consideration to the subject which cannot be given by this haphazard method of having the total membership make sugges-

tions for nominations; and this amendment goes further, Mr. Chairman, to prevent from consideration any section, or any group of men from putting in nomination a candidate. Upon the request of any twenty-five members additional names, for any office, will be added to this ticket.

I hope that the motion now before you will not be favorably acted upon, because it at once shuts out consideration of the other amendment.

PRESIDENT EARL: Has any one else anything to say in regard to the question before the house?

MR. A. H. MEYERS, Columbia, Pa.: I am very glad to hear Mr. Sherrerd's suggestion. I got into the city this morning. I think I can speak for some of the members who are not very often heard on the floor of this Convention, men who are not identified with the actual management of the Association but who have its interest at heart. There seems to be a feeling that the present method of nomination of officers is not in touch with the membership at large, that it is practically a blind pool in which a man has no chance; and I think the suggestion made by Mr. Sherrerd will offer a little bit more of an opening for the smaller representatives.

MR. HATTON: This is a pretty serious matter, and I think we ought to have a few days before we would know how to vote upon the matter. I would suggest that action on the amendments be postponed until later in the Convention. I move that further action on this matter be postponed until Thursday of this week.

MR. CHESTER: I second the motion.

MR. HATTON: I suggest that some mimeograph copies be made so that we can digest them and we will know what they mean.

MR. SHERRERD: Is it worth while to put the question off? It seems to me that a motion calling for a vote on one or the other of these amendments might be considered. I do not want to say that the vote should be taken today on an important question like this.

PRESIDENT EARL: The amendment is before the house, gentlemen; what is your pleasure? All in favor of the amendment, which is to the effect that we postpone consideration and final action on these two proposed amendments until Thursday, and in the meantime that mimeographed copies of both amendments be distributed to the membership here, will please say, "aye," contrary, "no." The motion is carried, and it is so ordered.

POSTPONED DISCUSSION OF PROPOSED AMENDMENT

Thursday, May 13, 1915, 11 a.m.

The amendments having been distributed in mimeograph form to the members at the Convention, were now considered and further discussed.

MR. MORRIS R. SHERRERD: Since these have been distributed the members are pretty familiar with them, for the purpose of bringing the suggested amendments before the Convention, I move the adoption of the amendments providing for a Nominating Committee.

The motion was seconded.

PRESIDENT EARL: It is moved and seconded that the amendments proposed by Mr. Sherrerd, and others be adopted.

MR. MORRIS R. SHERRERD: I understand that it would leave the matter in the hands of the Executive Committee as to the day when nominations shall be made since the Executive Committee can, if the amendments suggested by those who have signed the request are adopted, direct that the nominations, in accordance with this new provision of the Constitution, be made this afternoon. It seems to me that this ought to be done, so that the matter does not go over for a year, because if the amendment is adopted, then it ought to be made operative at once. The question of making the nominations during the period of this Convention should be acted on so that final letter ballot for officers can go out under either form of the amendment which may be adopted for next year's nominations.

MR. THEODORE A. LEISEN: Would not that be amending the Constitution after this Convention? And would that be in accordance with the Constitution?

SECRETARY DIVEN: One amendment was brought up before the Executive Committee at this Convention, and it is in order.

MR. MORRIS R. SHERRERD: Both were, Mr. Secretary. They both stand in the same position.

PRESIDENT EARL: If there are no other suggestions, I suggest that the ballots be distributed and a vote be taken for the Sherrerd amendment, or for the Executive Committee's proposed amendment. I think that would be the proper way to designate them.

MR. MORRIS R. SHERRERD: Can't you call them one "Nominating Committee" and the other "Letter Ballot"—mark one "For Nominating Committee" and the other "For Letter Ballot?"

PRESIDENT EARL: Does any one desire to discuss the desirability of the amendments before they are voted upon?

MR. SEABURY G. POLLARD: I suggest that the gist of the amendments be stated, or that they be read. I think quite a number are not familiar with them.

MR. MORRIS R. SHERRERD: I would like to make clear the one suggested by those who have signed the request with me. It would give the five men who would be selected by the Convention as the representatives of the five districts designated, a chance to get together at the Convention and consider the best good of this Association in presenting a ticket which would be sent out to the membership as the Nominating Committee's ticket within six months after the Convention; and during the next three months additional nominees could be placed on the ticket, which would be prepared by the Secretary, upon request of twenty-five members; the Nominating Committee's candidates to head the list for each office, and any additional candidates to be added alphabetically. I would also like to say that the suggested amendment offered by the Executive Committee seems to me to lend itself to a situation which would be very awkward in connection with other parts of the Constitution.

The Executive Committee suggested an amendment providing that nominations shall be made upon letter ballot which is an indiscriminate way of getting at any concerted action.

The Constitution also provides that no two members of the Board of Trustees shall be from the same state. Under the operation of that suggested amendment you can see that it is quite possible that those who would receive the requisite number to be on the ticket, namely twenty-five votes, might mean two or three gentlemen possibly from the same state, and in that case there would be no nomination before the membership for those offices which would conform to the provision of the Constitution. You could not elect two of those gentlemen, because they would come from the same state and you would have no other name on the ticket to give concerted action.

I would also say that it seems to me an unfortunate way to leave the nominations of our officers to be jockeyed around by one or two individuals, as the method of indiscriminate selection does. It would be unfortunate, and would not give due consideration to the best interests of the Association.

It has also, in my judgment, taken away a very decided interest in the Conventions. A feature of the Convention program which is of interest to all of us, I think, is that there be a chance to have some consideration given as to who shall be our officers; and when it is done by letter ballot, as I have heard a number of men say, they had no particular choice or desire, they simply followed what was suggested to them; but if it were done by proposing names by the Nominating Committee, a plan which is easily workable, in other words, the method of procedure would be that representatives from New England who are in attendance at the Convention could agree to meet the night before the nominations are to be made, upon the request of some one that they meet in such and such a room to consider whom they should nominate, and the next morning some one gets up and says, "Our members from New England have agreed to suggest the name of Mr. _____ as our representative on the Nominating Committee"—and so on with the other sections, those that are here in attendance could select as a representative from their respective sections, a man who is here in attendance at the Convention, and then the gentlemen could get together before the Convention adjourns and discuss the matter, and then either by correspondence, or by agreement, send out a suggested ticket which would represent the consensus of opinion of, at least, five men who represented different sections of the country, as to who would best serve this Association as its officers.

I would, therefore, gentlemen, ask your favorable consideration of the amendment which would provide for a Nominating Committee.

PROF. EDWARD BARTOW: The present method, that we might call the "Primary" method, brings the Association before the members during the year; it keeps the Association before the membership because of the sending out of the letters requesting nominations, and it is rather a good thing to keep up interest between sessions. The present scheme should be continued for at least another year to give it a thorough trial.

A MEMBER: I just want to relate a little personal experience as to this ballot proposition, and state why I am heartily against it, and in favor of the Nominating Committee. The Nominating ballots were sent around, and I presume they went to all of the gentlemen. When I got them, I went to one very popular gentleman and I said, "Who do you know that wants to be Trustee? Who do you know that wants to be Vice-President?" He could not tell and I did not know; and I dare say that ninety-five per cent of the members here either did not vote at all, or maybe some member voted for me, and I voted for another member, and somebody else voted for somebody else. A few people if they wanted to get together and vote for somebody, could keep the thing forever and forever. I am heartily in favor of this Nominating Committee proposition which provides that the members of that Committee be from the different districts of the country, which seems perfectly fair. If there can be any objection to it, I can not see it.

MR. A. A. REIMER: May I raise a question at this point in connection with the first amendment? The terms are very definite so far as defining the location of the New England States; but when we come to the Middle States, Southern States, and Central States, it seems to me that the line of demarcation is not quite so clearly drawn, and it might be well to have those other divisions definitely stated. Now a good many of us remember when we were in school that we had some divisions that we remember as "Middle Atlantic States," "Central States," and so on. That is a long while ago, and perhaps some of us do not remember just which states are embraced in those divisions. It seems to me that it might be well to define that particular point more clearly.

MR. C. E. DAVIS: I think it would be a good thing if the Executive Committee would name the particular states comprised in those respective districts.

MR. MORRIS R. SHERRERD: It seems to me that it can properly be left to the Executive Committee, to announce which states are included in each particular division. I understand that it is quite definitely understood what those divisions include.

MR. DOW R. GWINN: I did not expect to have anything to say on this subject; but as I understand, the motion is now on the amendment to the Constitution as proposed by Mr. Sherrerd; is that right?

PRESIDENT EARL: The vote is as between the amendment as proposed by Mr. Sherrerd for nomination by a Nominating Committee, or by letter ballot as recommended by the Executive Committee.

MR. DOW R. GWINN: When this matter was referred to the Executive Committee, we went over the report of the Canvassing Board and considered their recommendations very carefully

I would like to try out the constitution as we now have it, with the slight modification as recommended first by the Canvassing Board, and modified slightly and recommended by the Executive Committee. I believe that is the best proposition before us.

A MEMBER: One thing that has developed in this recent election is that we delegates, at least I for one, have received cards in the mail suggesting that I vote for this man, or that man. I received a card calling my attention to a man, and although I am quite a regular attendant at these Conventions, and have attended them for the last ten or fifteen years, one must have something by which he can remember a man, and remember whether he is a consulting engineer, or a water works man, or an active superintendent, or something of that kind—I believe I am going to say it out frankly—I have the highest regard for all of the consulting engineers, but I do not believe the Water Works Association here ought to have a majority, or practically all of the offices controlled by the professional end of it. I believe that the little fellows in the Associa-

tion ought to have, at least, a voice in the organization—that is the way I feel about it.

MR. C. W. WILES: I would like to inquire of the Secretary how many members of the Association cast their votes this year. That will give us some idea of how many took an interest in the election of the present officers at this time.

SECRETARY DIVEN: You mean votes for nominations?

MR. C. W. WILES: Yes, sir.

SECRETARY DIVEN: About twenty-five per cent. There were two hundred and forty-seven ballots cast.

MR. C. W. WILES: That shows the interest.

SECRETARY DIVEN: That was for the nominations. There were over six hundred votes cast for election of officers.

MR. J. WALDO SMITH: The criticisms about the old committees are fully covered by Mr. Sherrerd's amendment. I think we all agree with the last speaker, that the "little fellows" should have a chance, and this is just the way to give them a chance. By the present method we are just going at this blindly. It gives a certain class of men an opportunity that we do not want them to have, and I am heartily in favor of this change. We thought it was desirable when the change from the old method was made, which at its best was not a good one. I do not think the present method is very much of an improvement on the old one. I do think that what is proposed by Mr. Sherrerd would result in benefit to the Association.

MR. JERRY O'SHAUGHNESSY: I think Mr. Sherrerd's amendment improves the present method very much, but I do not think it is exactly what is wanted. We have wandered from the beaten path which leads to the election of officers and the place of holding our conventions. There is some reason for it. Somebody wants something done that would not do to let the common herd know about.

Yesterday, a gentleman from St. Louis asked me to vote for that city. I told him, "The cards are stacked, you have no chance; I will vote for St. Louis, for you, but it won't do any good." He said, "Yes, we have a chance." Thereupon I gave him some additional reasons as to why he had none. Afterwards, in the lobby of the hotel, he remarked, "You are a pretty wise old gazaboo."

It seems to me that a convention like this, composed of the class of men it is, that you can better judge from the assemblage who would be qualified to represent you as your officers than to have a nominating committee, or to have any other agency work for you and choose your place of convention or nominating or electing your officers. You men are certainly capable of attending to your own business; if not, you should not be here and somebody made a mistake in selecting you for the place you now hold.

I believe the amendment offered by Mr. Sherrerd comes nearer to the proper method of doing business than does the present one, but I would say further that it is my belief the day will come when the majority of the American Water Works Association will agree with me that it is better to attend to your own business and not delegate it to others.

MR. GEORGE HOUSTON: At the Louisville Convention I was inquiring as to who were the candidates for Trustees. I was given a list of names. Amongst them was Mr. Henderson. I immediately got myself acquainted with the different gentlemen who were candidates, and I said, "I want you to vote for Henderson as from what I learn he is the best qualified of any." Henderson was elected. What would I have known about the different candidates under our present system, or under the system proposed by Mr. Sherrerd? One of the main points of interest that I had in my early days attending the Convention was the opportunity that we were going to have to elect officers. You know we all like to vote, and we like to know if possible, the qualifications of the men we are going to vote for. I heartily agree with Mr. O'Shaughnessy that we ought not to adopt either one of these amendments to the Constitution, but that we ought to have another one that would enable us to go back to our original method, as he suggests, to make the nominations here on the floor and the elections here on the floor, then we will get somewhat near to what the great body of us really want.

MR. J. N. CHESTER: Mr. Chairman, I believe that Mr. Sherrerd's motion is the best that has been proposed here. I recognize all of the objections that have been brought up. It has been tried out in the American Society of Civil Engineers, and it has worked out fairly well. Mr. Sherrerd has, however, proposed an even better plan than that of the American Society of Civil Engineers. The natural result of any vote that is taken is that the congested districts are going to control if you give them the opportunity. Mr. Sherrerd's amendment distributes the members of the Committee into districts, and while I can not say that it absolutely disregards congestion, it does in a great measure, and that is what we must do. And I would add to it the rotation by districts of the Conventions. It goes without saying that the congested districts can always have a majority in this Convention, they can vote the Convention just where they see fit to put it. That is, of course, the majority rule, and we all say that it is right, but then it is not right for just a few big congested districts to divide the Conventions up and rotate them around between them.

I have no fault to find with the selections made. If too far away I stay at home; but I have heard a great many mutterings in the last few years about the way the Convention has been swayed. While the majority seem to prefer the big cities, we have our poorest Conventions in the big cities. It is a question whether we want to see sights or attend the Convention. If we add to Mr. Sherrerd's amendment a provision for rotating the Conventions, that they shall go from district to district, that it can not come back to a particular one until it has been to all of the rest, then I would like it a little better.

MR. MORRIS R. SHERRERD: That would naturally follow if this amendment is adopted; it does not follow as a matter of constitution, but it seems to me that that would be the logical thing.

MR. J. N. CHESTER: Let us make it a matter of constitution.

MR. MORRIS R. SHERRERD: It is not germane to this particular amendment.

MR. J. N. CHESTER: Well, I will add a clause compelling the Conventions to rotate by districts. If it is a good thing to send the

Conventions around over the country and get members in, why, let us do it.

SECRETARY DIVEN: That necessarily would be an amendment to another section of the Constitution. We could not add it to this section very well.

MR. THEODORE A. LEISEN: Without entering into the relative merits of the present and the suggested method of nominating, the speaker would like to point out that the amendment suggested by the Executive Committee, in reality is not a change in the intent or spirit of the present Constitution, but is merely a necessary correction to straighten out certain difficulties which have become apparent in connection with the nominating ballots; the specific difficulty which it is intended to remedy being the avoidance of having any one name placed on the final ballot for several different offices.

Under the wording of the Constitution, as it now stands, any one person might become a nominee for President, Vice-President, and for Treasurer and possibly also for a Trusteeship and the Committee would have no option but to place his name on the final ballot for all of these offices, and this is not considered wise or desirable. It was to get away from this difficulty that the amendment recommended by the Executive Committee was proposed. If the matter is to remain in abeyance for another year, or indefinitely, as the last motion provides, the speaker would suggest that in order to straighten out the difficulty mentioned, the amendment recommended by the Executive Committee had better be passed at this time and the Constitution can be revised later and the method of nominating officers changed as may seem best in the future.

PRESIDENT EARL: The question is on the original motion as made by Mr. Sherrerd for a vote as between the two methods—the method by Nominating Committee as recommended by Mr. Sherrerd and the signers on his petition, and the method by letter ballot, which is a continuation of the method described in the present Constitution, with the modification recommended by the Executive Committee. We will call for a standing vote. All in favor of the method of Nominating Committee will please rise.

A rising vote being taken as above, resulted in the vote of seventy-one in the affirmative, and a negative vote being called for, nobody rose.

SECRETARY DIVEN: In order to put this into effect there will have to be an election held during this Convention. I suggest that it be made a special order for five o'clock this afternoon.

PRESIDENT EARL: It will be made the special order for five o'clock. The gentlemen from each section will have to make arrangements to get together prior to that time, and they can introduce their nominees at five o'clock.

The undersigned propose the following amendments to the Constitution of the American Water Works Association:

ARTICLE VI: SECTION 5; Change to read: *Before the close of each annual convention, the executive committee elected to serve during the ensuing year shall organize and elect a secretary and an editor, to serve until the close of the next annual convention, or until their successors are chosen.*

ARTICLE VIII: SECTION 1: In the fourth line change the word "outgoing" to "incoming."

N. E. Bartlett

W. R. Young

C. E. Davis

E. Wegman

H. W. Streeter

THE SECRETARY: The Constitution as it now stands provides for the election of Secretary and Editor and the appointment of the Standing Committees by the outgoing Executive Committee; the object of this amendment is to change that to the new or incoming Executive Committee.

MR. THOMAS: Almost everybody will concede that the incoming officers ought to elect the officers that are to coöperate with them. I move that that last proposed amendment be adopted. I hope the motion will be adopted.

The motion was seconded.

MR. SHERRERD: I agree with Mr. Thomas. I hope the amendment will be adopted.

The question was now taken on the adoption of the last amendment, and the same carried.

MR. HENDERSON: I move that the recommendation of the Executive Committee that Mr. John Caulfield be made an honorary member be adopted. The motion carried unanimously.

MR. JOHN CAULFIELD, St. Paul, Minn.: Mr. President and Gentlemen, I certainly appreciate the honor conferred upon me by electing me to this high position. You have been more than kind to me since I joined the Association in 1887. This I think is the crowning honor which you have bestowed upon me. I remember the size of the Association and the small attendance that we had in those early days. I have attended the meetings for I think this will be the sixteenth consecutive year. I have enjoyed the meetings and I enjoy meeting the older members. That joy has been mixed with sadness as I note the annual decrease of our old members and reflect that there will be a time when probably a 1900 member will be considered an old member.

I thank you again for the honor.

PRESIDENT EARL: The next order of business is the report of the Secretary.

Secretary Diven then read his report on the state of the membership, as follows:

MEMBERSHIP

Active:

Last report.....	923		
Elected to membership.....	220		
Restored.....	7	1150	
	—		
Losses: Died.....	7		
Resigned.....	16		
Dropped.....	98	121	1029
	—	—	

Corporate:

Last report.....	68		
Elected to membership.....	9	77	
	—		
Losses: Resigned.....	2		
Dropped.....	5	7	70
	—	—	

Associate:

Last report.....	122		
Elected to membership.....	19	141	
	—		
Losses: Resigned.....	11		
Dropped.....	7	18	123
	—	—	

Honorary:

Last report.....	7		
Elected.....	1	8	
Losses: Died.....	1	1	7
Total Membership.....			1229

SECRETARY DIVEN: The change in the Constitution which changed the time that members should be carried from two years to one has had the effect during the past year of causing more members to be dropped than has ordinarily been the case; as under the old Constitution they would not have been dropped within three years.

IN MEMORIAM

HONORARY MEMBER

JOHN GALBRAITH.... Toronto, Ont.

ACTIVE MEMBERS

G. R. BROWN.....Missoula, Mont.
 JAMES J. FERRIS.....Jersey City, N. J.
 S. A. GAILEY.....Altoona, Pa.
 EMIL KUICHLING.....New York, N. Y.
 HENRY LAUTZ.....Pekin, Ill.
 WALTER A. MCFARLAND.....Washington, D. C.
 JOHN F. SPRENKEL.....York, Pa.

REPORT OF TREASURER

TROY, N. Y., April 1, 1915.

Mr. H. E. Keeler, Chairman Finance Committee, The American Water Works Association, Chicago, Ill.

Dear Sir: Permit me to submit my report as Treasurer of the American Water Works Association for the year ending March 31, 1915.

The funds of the Association are on deposit with the Troy Trust Co., Troy, N. Y., as per the order of your Committee.

The receipts during the year were as follows:

Balance April 1, 1914.....	\$1,064.24
J. M. Diven, Secy.....	10,683.84
Interest on deposit.....	88.57
Total.....	\$11,836.65
Disbursements as per cancelled checks and collection charges.....	7,568.50
Balance, April 1, 1915.....	\$4,268.15

The interest on the daily bank balance during the past year amounted to \$88.57, which is \$31.23 more than during the previous year.

Attached you will find certificate from the Troy Trust Co., showing a deposit of \$4,279.50 at the close of business on March 31, 1915. From this balance there should be deducted the following unreturned checks.

Deposit as per certificate.....	\$4,279.50
Unreturned check Voucher 578 ck. 746. Stowell & Son....	11.35
Balance.....	<u>\$4,268.15</u>

The cancelled checks and vouchers with the book of the Treasurer are submitted for audit.

Bank balance April 1, 1915.....	\$4,268.15
Bank balance April 1, 1914.....	<u>1,064.24</u>
Increase.....	\$3,203.91

The Treasurer is under \$5,000 bond as per the order of your Committee. Permit me to suggest that the amount of this bond should be increased if such large deposits are to be maintained.

Respectfully submitted,

JAMES M. CAIRD.

TROY, N. Y., April 5, 1915.

This is to certify that the American Water Works Association had on deposit with the Troy Trust Company at the close of business March 31, 1915, the sum of Four thousand two hundred seventy-nine and 50/100 (\$4279.50) dollars.

THE TROY TRUST CO.,

By Jas. H. Caldwell, *Chairman*.

REPORT OF FINANCE COMMITTEE

To the Executive Committee and Members of the American Water Works Association:

Gentlemen: Your Finance Committee beg to report that they have examined and audited the books of the Treasurer and Secretary and find them well and accurately kept.

Your Committee further find from the certificate of the President of the Bank, where the funds of the Association are kept, that the balance shown to be on hand by the Treasurer's report at close of the year ending March 31, 1915, is on deposit to the credit of the Association, and that all bills presented and certified for the year have been paid.

Authority has been given your Finance Committee, by the Executive Committee, to invest any surplus funds that, in their judgment, can be properly set aside, in municipal or state bonds and a beginning will be made at once to create a reserve fund in the hope that the Association may, in due time, have something to fall back upon in case of emergencies or unforeseen necessities.

Your Committee recommend that in the future all disbursements be governed entirely by funds appropriated for the various activities of the Association's work, and beg to submit the following for the year, beginning April 1, 1915.

There should be, and there is hereby appropriated out of any funds in the treasury of the Association:

For Convention purposes.....	\$550.00
For Office and Postage purposes.....	650.00
For Election purposes.....	75.00
For Committee purposes.....	200.00
For Section purposes.....	500.00
For Office equipment.....	50.00
For Insurance.....	50.00
For Rents.....	150.00
For Salary of Secretary } For Salary of Editor }	1500.00
For Printing, distribution and all other charges incurred in publishing the <i>Association Journal</i> , except salary of Editor.....	5000.00
For Contingent expenses.....	500.00
	\$9225.00

Moneys hereby appropriated shall not be transferred from one fund to another fund, and no indebtedness shall be incurred beyond the appropriation herein named for any particular purpose.

Your Committee, judging from past experience, believe that the amounts herein recommended are adequate, and within the resources of the Association.

Respectfully submitted,

H. E. KEELER	} Committee.
HOWARD DILL	
H. B. MORGAN	

REPORT OF MEMBERSHIP COMMITTEE

MINNEAPOLIS, MINN., May 8, 1915.

Mr. President and Members of the American Water Works Association:

Your Membership Committee beg leave to report that the past year has been one of great growth not only in number but in prominence. The water works officials throughout the world together with the engineers, chemists, and bacteriologists have been seeking membership to such an extent that it seems to us it will be only a very short time before we can probably boast of a membership of at least 5000. During the past year 220 new members have been admitted to active membership from 33 states and 6 foreign countries as follows:

Alabama.....	1	New Jersey.....	8
Arkansas.....	1	New Hampshire.....	1
California.....	6	New York.....	20
Connecticut.....	5	North Carolina.....	1
District of Columbia.....	3	North Dakota.....	1
Florida.....	1	Ohio.....	18
Georgia.....	2	Oregon.....	1
Illinois.....	64	Pennsylvania.....	6
Indiana.....	2	Rhode Island.....	1
Iowa.....	10	Tennessee.....	4
Kansas.....	4	Texas.....	4
Kentucky.....	5	Virginia.....	1
Louisiana.....	1	Washington.....	4
Maine.....	1	Wisconsin.....	1
Maryland.....	4	Australia.....	4
Massachusetts.....	7	Canada.....	4
Michigan.....	6	Canal Zone.....	2
Minnesota.....	1	Hawaii.....	1
Missouri.....	10	Japan.....	1
Montana.....	1	Russia.....	2

At this time we wish to express the Committee's appreciation of the good work done by the members of the Association in getting so large an increase to our membership and especially to our faithful director, Mr. Edward Bartow, who has been instrumental in bringing to the Association eighty-seven new members, and we trust this work will be an incentive to all members and during the coming year the new Committee will find all our members looking out for new members and a great growth can be reported at the next Convention.

Thanking the officers of this Association for the courtesies extended to us and the members for their coöperation, we are

Very truly yours,

W. R. YOUNG, *Chairman*.

MORRIS R. SHERRERD,

JAMES H. CALDWELL

REPORT OF PUBLICATION COMMITTEE

JOHN W. ALVORD, Chairman: The Publication Committee would like to request a little more time. There are several pretty serious questions coming up in the way of publications due to the amalgamation of new sections and the great volume of papers that are being presented, and the question with regard to the income from the advertising that has heretofore supported the printing of those papers by the local associations.

The Publication Committee are giving this matter serious con-

sideration, and wish the opportunity of meeting once or twice more during this convention.

PRESIDENT EARL: If there is no objection, the Publication Committee will be given further time for their report.

REPORT OF ELECTROLYSIS COMMITTEE

MR. DABNEY H. MAURY, Chairman: Mr. President, your Special Committee on Electrolysis find nothing which they wish to add to or change in their previous report.

REPORT OF COMMITTEE ON REVISION OF STANDARD SPECIFICATIONS FOR CAST IRON PIPE AND SPECIALS

The Secretary stated that Mr. John H. Gregory, Chairman of the Committee, was not able to be present, but had written reporting progress and asking that the Committee be continued to complete the work. The Committee are endeavoring to establish a standard that will be universal and have met with a similar committee of the New England Water Works Association and agreed on most points. The Committee have, also, had some correspondence with committees in Europe, one member of the Committee meeting with one such committee, to make a universal standard.

On motion of Mr. John Caulfield, duly seconded, the request of the Committee was granted and further time allowed to complete the work.

REPORT OF COMMITTEE ON STANDARD SPECIFICATIONS FOR WROUGHT IRON PIPE

MR. A. A. REIMER, Chairman: *Mr. President and Gentlemen:* Your Committee have been unable to get together at this Convention as yet.

The work has been carried on by the members, but it is a matter that will require a great deal of time. The research work necessary is something that can not be finished up in a month, or a year, or even in two or three years, because it requires the test of time. The Committee are short-handed at the present time. Mr. T. C. Hatton, resigned from the Committee owing to his removal and entrance into other lines. Mr. Emil Kuichling, of New York, died.

Your Committee wish at this time, if in order, to offer the following resolution:

Resolved: That the sympathy of this Association be extended to the family of Mr. Emil Kuichling; and that official recognition be taken at this time and in this way by an expression of the regrets of the Association at the loss of Mr. Kuichling, and that the Secretary be directed to forward such official regrets or notification of such official regrets to the family of the deceased.

Motion seconded by numerous members and carried unanimously.

REPORT OF COMMITTEE ON PREVENTION OF STREAM AND LAKE POLLUTION

To the American Water Works Association:

Through some inadvertence, the members of the Committee on Prevention of Stream and Lake Pollution were not notified of the composition of this Committee until just prior to this Convention and, in consequence, no regular meeting of the Committee has taken place and no report has been prepared in advance. This report is submitted in the nature of a progress report and is presented as the individual expression of the Chairman, owing to the fact that no meeting of the Committee has been possible.

Considerable preliminary and investigation work has been done by the United States Government through the International Boundaries Commission in the interests of suppressing the unnecessary pollution of the chain of lakes and rivers which form the boundary between United States and Canada, and while the efforts directed along these lines have been purely advisory, they have stimulated an interest in the subject which is productive of good results and have awakened an interest in the cities and towns along these waters, looking to the construction of such works as may be found necessary for the treatment of sewage in such a manner as will at least lessen the pollution of these streams and lakes. It has brought to the minds of the officials responsible for the welfare of the several communities, a fuller realization of their responsibility in this matter and as a result, investigations are being made by several cities preparatory to the installation of sewage treatment or sewage disposal plants. The comprehensive report issued by the International Boundaries Commission has furnished a lot of valuable information descriptive of the general condition existing at the present time, showing the degree of pollution at various points along the boundary waters.

Efforts along similar lines are now being directed to the Ohio River, from Cincinnati to Louisville, and possibly at some other points, but no reports have as yet been issued regarding this last work.

It would seem pertinent to suggest that the energies of the National Government might be directed along the same line as covered by the work of the International Boundaries Commission on investigation of various rivers throughout the United States, which of necessity carry off the sewage of large cities, and whose waters are required for municipal supplies at other points below where such sewage is turned in.

This, in a brief and concise way, embodies about all that the Committee can report at this time. It is a subject which it would seem should be followed up by this Association and the Association through the medium of a Committee, should endeavor to keep in close touch with the situation, and it is hoped that in another year the report of the Committee may embody a statement of practical results which have followed the work already accomplished.

It may be stated as a matter of interest, that along the line of preventing pollution, individual efforts have been made in addition to the advisory work of the Government, to induce the management of the various passenger vessels along the lake routes to provide facilities for holding the sewage on the boats, so that it can be emptied at points where the least possible harm can result, and also to provide facilities on each steamer for treating the sewage in some manner, even though it be crudely done, so as to further lessen the danger of pollution when the sewage is emptied into the stream. An effort along this line is being made in Detroit, and it may be stated with some degree of success, in that the owners of the vessels have indicated their willingness to provide facilities for treating the sewage, if proper and convenient methods can be indicated.

Respectfully submitted,

THEODORE A. LEISEN, *Chairman.*

On motion the report of the Committee was received as information and the Committee continued.

REPORT OF COMMITTEE ON STANDARD SPECIFICATIONS FOR
HYDRANTS AND VALVES

MR. B. C. LITTLE, Chairman: The report is very brief, merely a report of progress. The Committee have been represented at several meetings through the presence of Mr. Diven and Mr. Caldwell. It is expected that the New England Water Works Association will adopt very soon their standard specifications for hydrants and valves. Possibly Mr. Diven will give a little further report as he has attended the meetings with the New England Water Works Association Committee. It will be well to continue this Committee for another year, at least, when we hope to add standard specifications for light weight valves, as well as reaching an agreement with the New England Association Committee.

MR. J. M. DIVEN: The standard specifications for hydrants and valves presented by this Committee have been adopted by this Association and are now in quite general use among the manufacturers. The Committee is only continued in an endeavor to make the standards adopted by this Association, or some modifications of those standards, a general standard. Members of your Committee met with a similar committee of the New England Water Works Association on two or three occasions, and came to an agreement on most points; after which the specifications formulated by the committee of the New England Association, with the concurrence of your Committee, were presented to the members of the New England Water Works Association, at a special meeting held in the city of Boston, April 15, 1914. With some modifications, asked for by the members of your Committee present at that meeting, the report was adopted, but three points requiring further consideration, which, owing to the changes made in the report at the meeting, were referred back to the Committee. Since that date your Committee have not heard from the committee of the New England Water Works Association concerning the points referred back, and no further action can be taken until they are heard from.

Meanwhile the standards adopted by this Association on report of your Committee are in active force and in quite general use by manufacturers. It is greatly to be regretted that the committees of the two leading water works associations cannot come to a final agreement and have a standard that all can use; but your Committee feel that they can do nothing further until action is taken on

the disputed points by the New England Water Works Association Committee.

MR. ROBERT J. THOMAS: We have one of the best Committees in the Association working on this subject. They are certainly trying to do all they can to carry out the recommendations of the President in regard to coöperation. The Committee have been very effective in their work with the like Committee of the New England Water Works Association; and no doubt at the next meeting of the New England Water Works Association our Committee will convince their Committee that our specifications are the proper ones to adopt, and that we will have, in regard to valves and hydrants at least, the same standard specifications.

Therefore, Mr. President, I move that the Committee's report be accepted as one of progress and that the Committee be continued.

Motion seconded and carried.

REPORT OF COMMITTEE ON WATER CONSUMPTION

MR. EDWARD S. COLE, Chairman: Mr. President, your Committee on Water Consumption presented their report, and it was printed in the March, 1915, *Journal* of the Association. Your Committee have tried, at least, to make a beginning towards the segregation of water consumption data; and we wish to express our appreciation of the reports received from water works officials. We have received, as the report shows, about one hundred and sixty-six reports from as many cities, and, as the diagram shows, the total consumption per capita has been plotted to a uniform scale. We have laid off the total meter registration for industrial purposes, and then we have laid off on the opposite end the total meter registration for domestic use; and in the space between, the white area, the unshaded portion represents the water unaccounted for through meters in those various cities.

Many cities make a very excellent showing, which seems to promise that more of this sort of segregation can be effected if we have more coöperation.

Our President in his address spoke of the advisability of standards, and your Committee feel that we are contributing a little in the line of standardizing the use of water for purposes of comparison.

Your Committee wish to make one suggestion, that is, that the well-known form of recording water works statistics adopted by the

New England Association should be amended by the addition of four columns giving the segregated uses of water by meter registration, being four classes of use that we have adopted and used in our report, namely, domestic, industrial, commercial and public.

With that suggestion, your Committee conclude their report.

MR. J. N. CHESTER, Member of Committee: Will emphasize Mr. Cole's remarks on this with just a little further suggestion as to how this work might be continued, not by this Committee, but as a permanent feature of our Association work. Some Committee on Forms, or Records, or Tabulation of Statistics might get to working on this, and the work be carried on in connection with a great deal of other work, and Mr. Cole's suggestion that the New England form simply be amended and adopted and put annually into the hands of each member of this Association be adopted. Some follow-up method might be adopted so that we could get a report from each member.

Now we have no complaint to make regarding responses that have been made to the requests sent out, having received something like one hundred and sixty-six replies; that, however, is a very small percentage of the number we were entitled to receive, had each member been as much interested in getting a report to us as we were interested in getting it from him. Our report would have been a great deal more useful to the members of this Association if it had been more complete, or had represented a larger number of the concerns or plants in the Association. But we appreciate, too, that records have not been kept in all cases. They are not going to be kept until there is some definite scheme provided whereby this information will be available. There is some data that have been obtained by the New England Water Works Association comprising a summing up of the annual reports of that district, which might well be added to our report. What little we have done and what information we have received have been of great benefit, more of it would be of more benefit. We are not going to ask that this Committee be continued, but move that a permanent Committee be appointed to standardize a form similar to the New England Water Works Association form, and that the consumption statistics be reduced to simpler elements, and be incorporated in that form.

The motion was seconded.

MR. WILLIAM J. HATTON: Before the motion is put, why control the Committee's action as to just what the form should be? Why not let it be phrased to allow the Committee to use some discretion? There may be other forms; there are some that the speaker would like to have the Committee take up; forms that would be very valuable in our work. Why not leave open the question of recommendation as to the form suggested by Mr. Chester instead of controlling the action of the Committee in submitting forms?

MR. J. N. CHESTER: It was not intended to hamper the Committee. The speaker is heartily in sympathy with the Committee having a free hand; but would like to have everything included that is in the New England blanks with reference to consumption statistics, at least, to have it include all the four divisions, so that we can find out how much of our water is not being accounted for at all, even though we have every tap metered. The speaker wants the Committee to have the broadest field, but not to complicate matters, so that if a blank is sent out the party getting it will think it so formidable that nobody will tackle it; that is one thing that we must guard against.

MR. J. WALTER ACKERMAN: In order to get unity of action, should not this Association formulate and its Committee present the same scheme for reports and accounts that has already been adopted and used, nearly identically, in the state of New Jersey by the Public Service Commission, by the Railroad Commission of Wisconsin, and by a number of other associations and bodies. These forms embody every feature which Mr. Chester desires.

MR. J. N. CHESTER: If the last speaker refers to the bookkeeping form, will not attempt to go into that matter at all; that is made up of a number of pages, whereas what we want to send out is something that could be compressed into one page. What is wanted is not bookkeeping forms, but an operating form that will show results for the year, and show it on a page or less; although consideration must be given to what the Public Service Commissions of the country are doing in the way of putting out forms, and our form must have relation to theirs.

SECRETARY DIVEN: Committee that Mr. Ackerman spoke of stopped a little bit short of getting up forms for making annual

reports. The Committee was continued with the idea that they would submit forms for reports to agree with the accounting system. If a new committee be formed for this purpose they should by all means take into consideration the accounting system that the Association has adopted.

MR. J. WALTER ACKERMAN: The speaker quite agrees with Mr. Chester that the form adopted must be as simple as possible, there is no doubt about that; but his remarks of a few minutes ago contained the key to the question exactly. He said that he realized that in a good many instances the plants have not the information to send to the Committee. Now the Committee referred to by the speaker provided a scheme for accounts that would give exactly the information that Mr. Chester desires.

MR. CHESTER: But it was too complicated to be put in use, there was too much of it.

SECRETARY DIVEN: Nevertheless the system has been approved by this Association and adopted by a number of public service commissions and water works, and any forms for annual reports adopted should conform to the system of accounts.

The Committee on Water Consumption have done good work and having the matter well in hand would be better able to handle the continuance of the work than a new committee; therefore move that the Committee be continued, without instructions, to prepare forms for reports.

PRESIDENT EARL: It is moved and seconded that this Committee on Water Consumption be continued, with full authority to get up such forms and data as they have suggested. Motion passed.

REPORT OF COMMITTEE ON STANDARD FITTINGS FOR WATER METERS

Two years ago a Committee was appointed, of which I have the honor to be Chairman, to revise the standards of meter lengths and meter connections.

This Committee did considerable correspondence with manufacturers and also among themselves during the first part of the year,

and at Philadelphia we were enabled to get the manufacturers together. We made a partial report at that time in regard to what we believed was the proper length to be established for these meters.

This year before this Convention was in session, the Committee made an effort to reach all of the manufacturers of meters. The manufacturers signified their willingness to meet this Committee here at this time, and we were very fortunate in having nearly all the manufacturers represented at this meeting.

While we did not arrive at a standard for all the meters, yet we did arrive at what we believed to be a better standard for the smaller sizes.

In the opinion of the Committee it was unnecessary to fix a standard for one-half inch meters, for five-eighth inch meters, or for one and a quarter inch meters, although we found from some manufacturers that there are some of the one and a quarter inch meters used.

In going over this matter with the manufacturers, the effort was to find some standard that would not interfere with present conditions either of the manufacturers or the users of these meters.

In fixing these sizes for lengths, which was the first matter to come up, and in going over the different lengths, we concluded after deliberation, that the length of the five-eighth inch meter from end of spud should be seven and three-eighths inches, but some of the manufacturers objected to this, and one manufacturer believed that it would be necessary to change his pattern to do this. This matter has not been fully investigated, and if it would be necessary for him to change his pattern, then seven and a half inches would probably be the length to be adopted.

In the three-quarter inch meter, they universally agreed that nine inches was the proper length.

On the one inch there was an agreement reached on ten inches and three-quarters.

Now as to the threads for these meters and couplings, the question was what thread would meet the present conditions.

After considering the matter, it was agreed that what was known as the Briggs standard straight thread would probably be more nearly universal than anything that we would establish to conform with what is being used. It was the sense of the Committee to use the Briggs standard straight thread using the next size larger than the size of the meter. For instance, with a three-quarter inch meter,

use Briggs one-inch thread, which is practically what we are using today. That is as far as they went into this matter.

This report that we are making today is only verbal. We hope to have a report fully prepared and have it printed in the *Proceedings* so that you may all have it for consideration between now and the meeting in New York, when, if there are any objections to the standards that we have suggested, or have used, they can there be discussed and finally acted upon.

In regard to the larger meters, the question arose as to whether they should be thread meters, with either male or female connections, or flange connections.

We found in discussing the matter with the manufacturers that the larger percentage of the one and a half inch, and the two inch meters that they sell, are sold with female threads, while the consensus of opinion of the Committee was that we would prefer to have a standard flange coupling, a 2-bolt coupling.

But it is not the intention of this Committee to interfere with the present conditions any more than is necessary, but to arrive at some fixed standard on which we can all agree to operate our plants. The intention of the Committee is to proceed further with this matter and prepare a standard set of specifications for these meters, adopting two different lengths, one for male connections and the other for flange connections. The objection raised by the manufacturers as to the adoption of the flange connections was that in making the flange on a meter they had to make it so heavy that it might be a burden on the producer of the meter. The trouble is that if these flanges are brought up parallel to each other, you can use a like flange on the meter, but if the meter should be a little out of line, you all probably have had experience in regard to the methods of the man who goes out to look after that meter. It is probably near dinner time when he is about to finish, and he does not want to lose any time, so he applies a wrench on the bolt and away goes the flange on the meter, and you have lost the bottom of that meter. Therefore you see the reason for the manufacturers insisting that they think it would be better to use on the one and a half inch and two inch meters, a female coupling rather than a flange coupling; but we hope at the next meeting that we will have this report prepared in full and have it published in the *Journal*, and in the meantime you can all have time to consider our recommendations, and if you have something better to offer, the Committee will be delighted to receive it.

In reference to these lengths of the larger meters, we have not changed our recommendations as to these lengths since last year, so that it will be unnecessary for me to go into this further.

Regret to say that the Committee are not prepared to offer you something for final acceptance or rejection; but almost all of you who have served on committees of this kind have experienced the difficulty of meeting all the conditions that surround a matter of this kind.

On motion of Mr. Diven, the above report was received and accepted, and the Committee continued until they conclude their work.

MR. MORRIS E. SHERRERD presented the following resolution:

WHEREAS, The operation and management of water plants are, or should be, conducted in the interest of their stockholders, which stockholders in the case of a municipally owned plant, are the water takers or inhabitants of such municipality, and

WHEREAS, The accounting methods prescribed for the public utilities by most, if not all of the Public Utilities Commissions of the various states require the charging of both sinking fund and depreciation against operation, and

WHEREAS, When the income from such utility is sufficient to provide for both sinking fund and depreciation, revenue which might otherwise justify a reduction of water rates, is by this method excluded from consideration in the making of such rates and

WHEREAS, It is not obligatory for private water companies to provide sinking funds for their bond issues, and earnings in excess of depreciation are distributed by them as dividends; and

WHEREAS, This method tends to place a municipally owned plant at a disadvantage and prevents its stockholders from getting their dividends in a reduction of rates;

Therefore, Be It Resolved: That it is the sense of the American Water Works Association, in convention assembled, that the attention of the Public Utilities Commissions of the various states be called to the inequalities resulting therefrom, and that they be requested to modify their requirements regarding this feature of accounting.

And Be It Further Resolved: That the Secretary is hereby instructed to forward a copy of this resolution to the various Public Utilities Commissions throughout the country.

MR. SHERRERD: I move the adoption of this resolution, Mr. President.

The motion was seconded.

MR. J. N. CHESTER: The whole matter is not stated in the resolution, wherein only the depreciation and sinking fund are mentioned. Every water works plant ought to make interest, depreciation and operating expense. The speaker does not believe in the sinking fund. It will not be fair to a profitably operated plant to eliminate the sinking fund and not mention interest; therefore, move to amend the resolution by including interest.

The amendment was seconded.

MR. SHERRERD: There is no objection to the inclusion of interest. It does not affect this resolution one way or the other. Interest is always to be charged against operation; there is no issue on that point. The only point to be brought out in this resolution is that the public accountants throughout the country have been heretofore so influenced by the managers of private plants that they have created a situation which dominates the public utilities commissions throughout the country. In other words, this resolution asks the Association to go on record as against establishing these methods in public plants. The method has been carried into the regulations that are applied by public utilities commissions.

To give you a concrete example in one city the plant has bonds outstanding to the extent of about \$12,000,000, and there is now in the sinking fund in the neighborhood of \$5,000,000 or \$6,000,000 to pay off these bonds which will be paid off in 1922 under the rulings of the public utilities commission. Not only the interest, operation and depreciation, but also the sinking fund is charged against operation; so that it militates against that city's being able to adjust its water rates at this time and give its present water takers the benefit of a reduction; whereas in the natural course of affairs when those \$8,500,000 in bonds are paid off from the sinking fund in 1922 there will be an opportunity to nearly cut the water rates in two for the benefit of the future.

The claim is that it ought to be so handled by utilities commissions that this adjustment of water rates can be given to the present water takers; in other words that the present generation ought not to pay the depreciation that will keep the plant up to the top notch and also pay the sinking fund that pays for the bonds. Of course at the end of the time they will not only have their plant by the charging of depreciation into operation, keeping it up to its highest efficiency, but they also will have paid for all their bonds,

during the same period of time, which does not seem to be a proper method of accounting to be applied by the public utilities commission. Also, that it does militate against a municipality in this way, that it prevents a municipality from giving to its stockholders the dividends that the private companies are able to give to theirs; while the private companies are taking advantage of this situation to say, "We will keep our rates up no matter what the municipality rate is." It gives them a chance to declare dividends, whereas the municipality can only complain against it to the citizens of the city.

After extended discussion which was taken part in by Messrs. J. N. Chester, C. B. Salmon, H. C. Hodgkins, Morris R. Sherrerd, Jerry O'Shaughnessy and Henry B. Morgan the resolution was on motion of Mr. Francis S. Luce, duly seconded, referred to the Executive Committee with instructions to report on it at the next annual Convention.

PRESIDENT EARL: We would like to hear a word from the newly elected officers. I will call on Mr. Nicholas S. Hill, Jr.

RESPONSE BY PRESIDENT-ELECT NICHOLAS S. HILL, JR., NEW YORK CITY

Mr. President and Members: I was congratulating myself that I was to escape this ordeal. Reminiscing seems to be the order of things this morning, particularly with Mr. John W. Hill.

As I look back to my earliest recollections of this Association, when I reflect upon the growth of the Association and the change in its spirit, when I see the increase in earnestness of purpose of those who attend the Conventions, and the improvements in the organization of the Association, I feel deeply the responsibility and the honor conferred upon any one who is connected with the office of president of an association which intimately touches the comfort and health of so large a portion of the population of this country. I am deeply indebted to the Association for the honor conferred upon me. All I can say is this, that I shall strive to do what I can to assist the progress of the Association during the coming year. (Applause.)

PRESIDENT EARL: I am deeply appreciative of the fact that Mr. Hill's election as President is most deserved, and I shall be very glad to see him assume the responsibilities that will fall upon him.

I congratulate the Association most sincerely upon its choice of President, and also upon its choice of Vice-President in the person of Mr. Metcalf, who I hope will say a word to you. (Applause.)

RESPONSE BY VICE-PRESIDENT-ELECT METCALF,
BOSTON, MASS.

Mr. President and Gentlemen: I do feel deeply grateful to all of you for this expression of confidence in electing me as your next Vice-President. I shall take great pleasure in serving you and working with the other members of the Board. I have been very much struck, as I have gone about in this country, particularly in the last two years, the greater part of which I have spent in the Middle West and on the Pacific Coast, with the growing spirit of coöperation which has been referred to by our President, and of which evidence has been given in a great measure in different parts of the country of late.

I remember two or three years ago when Mr. Karl Imhoff, Chief Engineer of the Emscher District, Germany, first came to this country. He came to Boston with a letter of introduction to us from Mr. Herrick. He said to me that he was more impressed by the friendly spirit of coöperation amongst the engineers in this country than by anything else he had seen here. He said it was not true of Germany, indeed that consulting engineers as such did not exist in Germany, that their method of doing the work was quite different there; that a man was called to a city to do an important piece of work, did it, and then passed from that city to another; but that there were very few men in the country who had had experience in various cities who were in general practice. In England, too, the condition is quite different, and as a result of the method of conducting business there, there was not the cordial spirit which you find in this country. He said, "Why, I find in New York the engineers speak in a friendly way of their active competitors, if I may so speak of them, in Chicago, or in Boston, or in any other city in the United States." I replied to him that it was true that there was a radically different attitude on the part of engineers in this country from that which existed abroad. That is

true in like measure amongst the water works men; and I feel that we have made far greater advances in this country as the result of that spirit of coöperation.

In different sections of the country, of course, you find that not only the problems are different but that they have been met in different ways, so that getting together annually in conventions, as we do here, is of the greatest advantage in threshing out different ways in which similar problems may be handled.

In passing it is perhaps interesting to note the friendly spirit of rivalry which exists in some of these associations. Since I have been at this Convention here, probably because I am from New England, particularly at the Executive Committee meetings I have been asked again and again, when the New England Water Works Association would come into this Association as a section? I think that those of you have who attended the meeting this morning and heard the constant references to the doings of the New England Water Works Association must clearly realize the feeling which some of your superintendents who are members of that Association, have toward this Association; and I do not think that the spirit of rivalry which exists, or which has existed in some years between these two Associations is to the disadvantage of either. On the other hand, and behind all of that, you do see a very admirable spirit of coöperation between the two, and they are constantly being made to come together on standard specifications and that sort of thing, so as to improve the practice generally in this country.

To those of you who are seriously entertaining the hope that the two Associations may one of these days come together, I would point out that the New England Water Works Association has recently reciprocated the courtesy which was extended by this Association to it, to the members at least, of joining this Association without the payment of an initiation fee.

In conclusion, gentlemen, I thank you again for electing me as your Vice-President, and would say that I look forward with a great deal of pleasure to working with the new Board. (Applause.)

THE SECTIONS

NEW YORK SECTION

At a meeting of the Governing Committee of the New York Section, Mr. J. Waldo Smith was chosen President of the Section and Mr. Allen Hazen, Secretary.

It was decided to hold three meetings during the winter of 1915-1916, but exact dates for the meetings were not decided upon.

ILLINOIS SECTION

MINUTES OF THE FIRST REGULAR MEETING OF THE ILLINOIS SECTION OF THE AMERICAN WATER WORKS ASSOCIATION

The first regular meeting of the Illinois Section of the American Water Works Association, corresponding to the seventh regular meeting of the Illinois Water Supply Association, was called to order by President Ely March 9, 1915, in the lecture room of Engineering Hall at the University of Illinois.

President Ely delivered an address which was referred to a committee for recommendations. The Secretary-Treasurer's report was received and Messrs. Amsbary, Talbot and Gerber were appointed an Auditing Committee. They later reported that the accounts were correct.

PRESIDENT'S ADDRESS

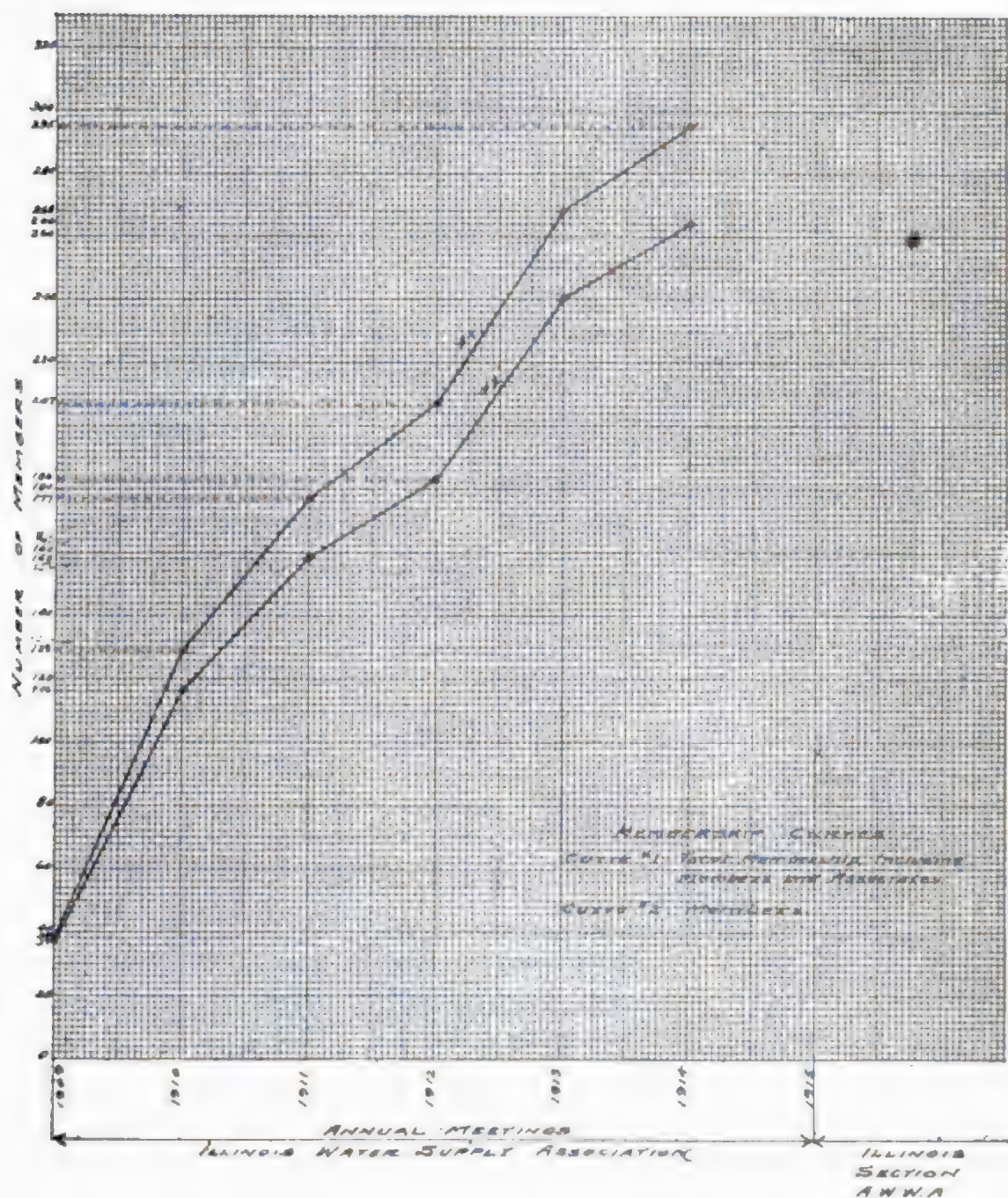
H. M. ELY

Superintendent Inter-state Water Company, Danville, Ill.

To the Members of the Association:

This is the seventh annual meeting of an organization of those interested in the advancement of knowledge concerning water supply and water works, and the purification and conservation of public water supplies throughout the state of Illinois.

In February, 1909, President James of the University of Illinois invited the water works men of the state to a conference with the State Water Survey concerning the important and vital question of the public water supply. At that conference a permanent organization was effected known as the Illinois Water Supply Association. This association under the able and energetic leadership of its secretary has grown in a very gratifying manner, not only from the standpoint of interest and benefit to the members, but also in point of increased membership. The growth in membership is best shown by the accompanying diagram, and shows an increase from 38, at the time of organization to 295 at the time of the 1914 meeting. The



lower curve represents the number of active members and the upper one the total membership including members and associates.

Referring to the address of Past President Cobb, the following may be quoted: "I think that the most important measure that we can adopt at the present meeting will be to become a section of the American Water Works Association." At the 1914 meeting the executive committee reported upon a proposition concerning amalgamation with the American Water Works Association, and recom-

mended that this question be submitted to a vote of all the members. Such a vote was later taken by letter ballot, with the result of 101 votes for the amalgamation to 11 against. On November 11, 1914 a special meeting was held in Chicago for the purpose of taking the necessary action for becoming a Section of the American Water Works Association. The proper action was taken and a petition presented to the national association. It is my great pleasure to announce officially that said petition has been granted and that our organization is now "The Illinois Section of the American Water Works Association" succeeding the Illinois Water Supply Association. Quoting again from the address of a past president, that of Mr. Parkin, "We believe that our association has found a permanent place among our state scientific associations." The speaker would call attention to the fact that we have not only found a permanent place among our state scientific associations, but have received recognition by a national organization.

This Association is a through passenger, having traveled over the rails of the Illinois Water Supply Association, has now come to a junction point, and without change of cars will proceed over the rails of the American Water Works Association. We will continue our meetings as heretofore, with consideration of subjects and problems existing under the local conditions in our own vicinity, comparatively speaking; will elect our own officers and the character of the meetings will not be changed. Let us put into the sectional organization the same interest and energy, and proceed with the same worthy purpose which has characterized the old association. We will give the above mentioned passenger an annual pass and expect him to report at least once a year, and perhaps again for an extra meeting. I think that the question of holding a one day meeting in the fall, of such character as our last November meeting, should be considered at this meeting.

I said put the same interest into the new organization; yes, I will say more interest. It is an advantage for us to be affiliated with the larger organization, and if that helps us we should be interested in the welfare of the parent association, and will be glad if the affiliation is of mutual advantage. It is believed that the sectional influence will be felt in the increase of membership of the national association. While it is too soon to judge definitely, consideration of the following facts seems to show that tendency. From a comparison of the membership in the American Water Works Associa-

tion for the years 1913 and 1914, according to states, it is seen that the increase in the state of New York is 32, New Jersey 17, Illinois 23, Pennsylvania 17, while the increase in the other states ranges from six to an actual decrease. New York and New Jersey combined to form the first sectional association, Illinois is the second. It will be noted these three states and Pennsylvania are the only ones in which there has been a noteworthy increase of membership. The increase in Pennsylvania is probably due to the holding of the Annual Convention in Philadelphia, but as to New York, New Jersey and Illinois, it is believed that the increase is due in a large measure to the sectional influence. The increase in 19 states is 127; the decrease in 14 states 28; no change in 16 states, leaving a net increase of 99 members in the American Water Works Association for year 1914. The fact that there was a decrease in 14 states, no change in 16 states, and only a small increase in the other states in which there are no sectional organizations, shows that there is a wide field for improvement in growth.

I believe that this movement, in which our own state is one of the pioneers, is spreading, and that many more states will see the mutual advantage in amalgamation, or in organizing sections in states where there is at present no state organization. Mr. W. R. Young, Registrar of the Minneapolis Water Department and Chairman of the Membership Committee of the American Water Works Association writes us that Minnesota is now organizing a state section. Mr. Young's letter reads as follows: "It gives me great pleasure to congratulate you on this work, and there is no doubt but that it will be one of the most prosperous state organizations affiliated with the parent branch."

We are informed that in Iowa there seems to be an unexpected demand among the water works men for such a society; that the organization of a state section is making steady progress; and that it is hoped to complete such organization and hold a meeting this spring. The Central States Water Works Association is considering the question of amalgamation, although no definite action has been taken as yet, but it is possible that that association may organize as three separate sections: Ohio, West Virginia and Michigan.

The speaker does not wish to convey the impression that our section is organized for the purpose of boosting the American Water Works Association. The wisdom of making this change has been passed upon by the association with the understanding that it does

not lose its identity; that we do not lose the benefits of our society, but gain by the connection with the national association. If by such action we benefit and strengthen the parent association so much the better for both the parent and the adopted child. This simile is not strictly applicable perhaps, for in the case of adoption of children, the same are dependent; the section organizations are not, or should not be; at least, ours is not. Your president also wishes to express his appreciation of the efforts and interest of the members and associates, for were it not for that interest, no secretary, however capable, could build up the association. The president desires also to thank the officers and committees for their efforts, and the members for their interest and attendance.

Let us hope that we may, and let us endeavor to continue under the new organization with the same spirit that has been shown heretofore, to the end that we may assist each other in our endeavors to faithfully and fairly serve our respective communities for the public good, that we may merit the same treatment by them.

FINAL REPORT OF THE SECRETARY OF THE ILLINOIS WATER SUPPLY ASSOCIATION AND FIRST REPORT OF ILLINOIS SECTION OF THE AMERICAN WATER WORKS ASSOCIATION

At the 1914 meeting the Association voted to appoint a Committee to present a statement to the members concerning affiliation with the American Water Works Association as a section. This report was submitted to letter ballot and the members voted in favor of becoming a section of the American Water Works Association. Accordingly a meeting was held in Chicago, an account of which was published in the March 1915 number of the *JOURNAL OF THE AMERICAN WATER WORKS ASSOCIATION*. The Executive Committee of the American Water Works Association have formed the Illinois Section of the American Water Works Association and have approved the constitution proposed by the special meeting held in Chicago.

Since the last meeting of the Illinois Water Supply Association the proceedings of that meeting have been edited and published. Fifteen hundred copies were printed, including 400 copies bound in cloth for members, associates and advertisers. Paper bound copies have been sent as exchanges to the Illinois Society of Engineers and Surveyors and the Indiana Sanitary and Water Supply Association. The proceedings of these associations were sent to members who had paid the 1914 dues prior to May 1. Owing to the affiliation with the American Water Works Association, exchange relations with the two organizations mentioned will be discontinued, and the papers presented at this and future meetings of the section will be sent to the Secretary of the American Water Works Association and after being approved by the Committee on Publications of the American Water Works Association, will be printed in their *Journal*.

The financial statement shows a balance of \$223.12. This compares favorably with the balance of \$120.66 a year ago. Since all dues are now paid to the American Water Works Association, the income of the Section will be confined to 25 per cent of the dues paid by active members, or \$1.25 per member. A statement received from Secretary Diven of the American Water Works Association shows 105 active members on March 1. That would entitle us to draw for the coming year an amount not exceeding \$131.25. This should be sufficient to pay the ordinary expenses of the Section as allowed by the constitution of the American Water Works Association.

The Secretary would suggest that the balance in the treasury together with any money which shall be received from back dues or sale of *Proceedings*, be held as a fund to pay for any special necessary expenses which should not be paid by the American Water Works Association, money to be paid from this fund on order of the President and Treasurer of the Illinois Section.

The Illinois Water Supply Association had in 1914 264 active and 31 associate members. Of these members, 178 resided in Illinois and 117 outside the state. Of these, outside of the state all but 29 have already joined the American Water Works Association. Of these, in the state 105 are now members, 7 have apparently satisfactory reasons for declining to transfer their membership and 66 have not yet been heard from. We should have an active membership of 150. The members of the Section should use every influence to increase the membership and make the Illinois Section a strong and powerful organization.

The report of the Publication Committee was given by Professor Talbot.

REPORT OF PUBLICATION COMMITTEE

In view of the fact that the JOURNAL OF THE AMERICAN WATER WORKS ASSOCIATION will be the medium for the publication of the *Proceedings* of the Illinois Section, the Publication Committee deem it proper to call attention to the value of the six volumes of *Proceedings* which have been published by the Illinois Water Supply Association as a contribution to the literature of water supplies and water supply engineering. The papers contained in these volumes are short crisp papers on a variety of subjects, and generally of a practical nature, along lines bearing on the quality of water supply and the construction and operation of water works plants. In thus calling attention to the material in the six volumes, the Committee wish to raise the question whether steps should not be taken to have the publication of the papers of the Illinois Section printed in the *Journal* in such a way, by notation and grouping, that the Section may be able to retain some individuality of publication. It is believed that such a form of publication would be helpful in assisting to maintain the high character of the programs of the meetings of the Illinois Section.

The March number of the *Journal* will contain the Constitution of the section. It is probable that the Constitution will be printed in pamphlet form. We recommend that a request be made to have a list of the charter members of the Illinois Section included in this pamphlet.

For another time, the Committee wish to call attention of the members to the valuable work of the Secretary, Dr. E. Bartow, in securing papers and in editing and printing the last *Proceedings* of the Illinois Water Supply Association.

Respectfully submitted,

A. N. TALBOT,
W. W. DEBERARD, } *Committee.*

H. E. Babbitt, Instructor in Municipal and Sanitary Engineering University of Illinois, read a paper entitled "Wash Water Salvage at Champaign and Urbana," which was discussed by Jennings, Mohlman and DeBerard.

W. F. Monfort, Consulting Chemist, St. Louis, Missouri, read a paper entitled "Relation Between Bacteriological Standards and Vital Statistics at Hannibal, Missouri." This was discussed by Bartow.

A paper by Langdon Pearse, Division Engineer, Sanitary District of Chicago, entitled "Loss of Head on Strainers of Water Filters," was read in his absence by the Secretary.

O. T. Smith, Superintendent and Manager Water Works Co., Freeport, Illinois, read a paper entitled "Experiences in Rebuilding and Reinforcing a Water Works System." This was discussed by Brandli, Smith, McGonigale, Reid, Roos, Allen and Strasser.

R. R. Parkin, Chief Engineer Water Department, Elgin, Illinois, read a paper entitled "Experiences with Artesian Well Water at Elgin." Adjourned.

An illustrated paper by Cass L. Kennicott, Vice-President and General Manager the Kennicott Co., Chicago, entitled "Soft Water," was read by Mr. Dunham.

Moving pictures showing coal mining operations, films obtained through the courtesy of the Bureau of Mines, were presented by Prof. H. H. Stoek of the University.

F. H. Kay, Assistant State Geologist of Illinois, read an illustrated paper entitled "Coal Resources of the Danville Area." This paper will be published by the State Geological Survey.

Frank DeWolf, Director Illinois State Geological Survey, read an illustrated paper entitled "Investigation of Artesian Water Supplies in the Chicago Area."

W. R. Gelston, Superintendent Citizens' Water Works Co., Quincy, read an illustrated paper entitled "The New Filtration Plant at

Quincy, Illinois." This was discussed by Langelier and Babbitt. Adjourned.

The third session was called to order at 10 a.m., Wednesday, March 10, 1915.

W. W. DeBerard, Western Editor, *Engineering Record*, Chicago, read a paper entitled "Kinks in the Control of Hypochlorite at Denver." It was discussed by Jennings and H. E. Jordan.

L. A. Fritze, City Chemist, Moline, Illinois, read a paper entitled "River Sand as a Filter Medium." Discussed by Amsbary, DeBerard and Ely.

S. C. Hadden, Associate Editor, *Engineering and Contracting*, Chicago, read a paper entitled "The Practical Value of Publicity to the Water Works Man." It was discussed by Gwinn and Hansen.

C. B. Williams, Hydraulic and Sanitary Engineer, Chicago, read a paper entitled "The Possibilities of Improved Water from Deep Wells in Northern Illinois."

A. N. Bennett, Assistant Chemist, State Water Survey, Urbana, and Edward Bartow, Director State Water Survey, Urbana, Illinois, read a paper entitled "Arsenic in Filter Alum." It was discussed by Graham.

C. A. Jennings, Chemist and Superintendent of Filtration, Union Stock Yards, Chicago, read a paper entitled "Bubbly Creek Filter Plant Adopts Liquid Chlorine Treatment."

Officers were elected as follows:

Chairman: W. J. Spaulding, Commissioner of Public Property, Springfield.

Vice-Chairman: Paul Hansen, Engineer State Water Survey, Urbana.

Treasurer: H. E. Keeler, The Rookery, Chicago.

Trustee to serve 3 years: F. C. Amsbary, Superintendent and Manager Champaign and Urbana Water Company, Champaign.

Edward Bartow was later elected Secretary by the Executive Committee.

The Committee on the President's Address reported as follows:

Your Committee appointed to consider the recommendations contained in the President's address report as follows: We believe that it is desirable to hold a one day's meeting early in October each year, the time and place to be decided by the Executive Committee. We suggest that the type of meeting

held in the fall of 1914 at Chicago is a good example of the character of meetings to which these may well conform.

WILLIAM T. BARNES,
A. N. TALBOT,
S. C. HADDEN.

BOARD OF TRUSTEES

Resolved: That all funds and other property of the Illinois Water Supply Association be placed in the hands of five trustees. These trustees in the first place shall be named by President H. M. Ely, but the Trustees acting at any time shall have power to fill vacancies caused by death, resignation, or otherwise. The Trustees shall have authority to expend and dispose of the aforesaid funds and other property according to their judgment and for the benefit of those who were members of the Illinois Water Supply Association or who shall be members of the Illinois Section of the American Water Works Association.

Resolution seconded and adopted.

President Ely appointed as the first Board of Trustees the following named, viz:

Messrs. H. E. Keeler, F. C. Amsbary, A. N. Talbot, W. D. Gerber and Edward Bartow.

Mr. C. M. Larson, Chief Engineer, Railroad Commission of Wisconsin, Madison, Wisconsin, read a paper entitled "State Regulation of Municipally Owned Plants."

C. G. Bennett, Mechanical Engineer, Illinois Utilities Commission, Springfield, read a paper entitled "The Illinois Utilities Commission and the Water Works Companies."

Douglas A. Graham, Principal Assistant Engineer, Dabney H. Maury, Chicago, read a paper entitled "The Application of the Theories of Regulation to the Management of Utilities."

Ralph E. Heilman, Assistant Professor of Economics, University of Illinois, read a paper entitled "Economic Aspects of Water Works Operation."

Edward A. Pratt, President Edward A. Pratt Audit Co., Peoria, read a paper entitled "Ancient and Modern Accounting for Utilities."

The following papers by authors who were not present were read by title:

"The Design and Operation of Intermittently Operated Water Purification Plants," by N. T. Veach, with Worley and Black, Consulting Engineers, Kansas City, Missouri.

"Cooled Drinking Water" by R. F. Massa, Manager, General Refrigerator Machine Department, H. W. Johns-Manville Co., Ft. Wayne, Indiana.

"The New Filtration Plant at Decatur, Illinois" (Illustrated), by Harry Ruthrauff, Commissioner of Public Property, Decatur.

"Choice of Alloys in Connection with Water Works Equipment," by Horace Carpenter, Engineer, Sanitary District of Chicago.

"Treatment of Water for Locomotive Use," by W. A. Pownall, Water Engineer, Wabash Railway, Decatur.

"Water Supply of Longview, Texas," by Paul E. Green, Civil and Sanitary Engineer, Chicago.

"Some Features of the Ontario Statutes and their Administration Affecting Water Supply and Sewerage," by F. A. Dallyn, Provincial Sanitary Engineer, Toronto.

"Water Prevention by Individual Meter versus District Meters," by R. O. Wynne-Roberts, Consulting Engineer, Regina, Sask.

The President was authorized to appoint a Legislative Committee together with other committees which might be necessary for carrying on the business of the Section.

Adjourned.

On March 11, the members visited Danville, Illinois, and inspected the stripping mine of Two Rivers Coal Co., the shaft mine of the Bunsen Coal Co. and the Danville Water Works. They were entertained at luncheon by the Interstate Water Co. of Danville.

IOWA SECTION

April 27, 1915.

To the Executive Committee of the American Water Works Association:

The twenty-eight men whose names are listed below have all applied for charter membership in an Iowa Section of the American Water Works Association. A copy of the constitution to which they have all agreed is attached to this formal application for a charter. All but five of these men are at present members of the American Water Works Association. These five men have agreed to apply for membership immediately upon the granting of a charter to the section. Indeed, two of the men, Mr. Judd and Dr. Albert, have already applied for membership. We believe that the formation of an Iowa Section will greatly advance the water works interests of the state. If the charter is granted, we hope to hold our first meeting for the election of officers and for the presenting of papers during the first week in June.

C. H. Streeter, Cedar Falls, Iowa; W. A. Judd, Mason City, Iowa; L. H. Goebel, Cedar Rapids, Iowa; Wm. Molis, Muscatine, Iowa; John W. Pray, Fort Dodge, Iowa; Jack J. Hinman, Jr., Iowa City, Iowa; Dr. C. S. Woods,

Iowa City, Iowa; Dr. Henry Albert, Iowa City, Iowa; W. A. Hostetler, Iowa City, Iowa; J. H. Dunlap, Iowa City, Iowa; K. C. Kastberg, Boone, Iowa; B. J. Stedman, Dubuque, Iowa; C. N. Kinney, Des Moines, Iowa; J. P. Berry, Waterloo, Iowa; Charles J. Fox, Oskaloosa, Iowa; Francis D. H. Lawlor, Burlington, Iowa; James P. Donahue, Davenport, Iowa; Horace A. Brown, Ottumwa, Iowa; Mr. Wm. Coppock, Council Bluffs, Iowa; J. Chris Jensen, Council Bluffs, Iowa; Henry M. Hanssen, Carroll, Iowa; M. I. Evinger, Ames, Iowa; G. E. Shoemaker, Waterloo, Iowa; B. N. Kinnaird, Des Moines, Iowa; Charles R. Henderson, Davenport, Iowa; Thomas N. Hooper, Davenport, Iowa; J. E. Roberts, Corning, Iowa; David Fisher, Davenport, Iowa.

A local committee of ten members has been in charge of the preliminary work for this Section. This Committee consists of the following men:

J. H. Dunlap, Iowa City, Chairman; C. H. Streeter, Cedar Falls; John W. Pray, Fort Dodge; L. H. Goebel, Cedar Rapids; W. A. Judd, Mason City; M. I. Evinger, Ames, Iowa; William Molis, Muscatine, Iowa; J. P. Berry, Waterloo; Dr. C. S. Woods, Iowa City; O. E. Klingaman, Iowa City.

Respectfully submitted,

J. H. DUNLAP, *Chairman.*

CONSTITUTION OF THE IOWA SECTION OF THE AMERICAN WATER WORKS ASSOCIATION

ARTICLE I

Name

The name of this society shall be "The Iowa Section of the American Water Works Association."

ARTICLE II

Object

The object of this Section shall be the same as that of the American Water Works Association, namely, "the advancement of knowledge of the design, construction, operation and management of water works, and the encouragement, by social intercourse among its members, of a friendly exchange of information and experience."

ARTICLE III

Headquarters

The headquarters of this section shall be at the State University of Iowa, Iowa City, Iowa.

ARTICLE IV

Membership

The membership shall consist of the members of the American Water Works Association residing in the State of Iowa.

ARTICLE V

Officers

SECTION 1. The officers of the Section shall be a Chairman, Vice-Chairman, Secretary-Treasurer, and two directors. These officers shall constitute an Executive Committee, of which the Chairman of the Section shall be Chairman and the Secretary-Treasurer shall be Secretary.

SECTION 2. The officers and directors shall be elected at the time of the annual meeting to hold office for one year. The Secretary-Treasurer shall be elected annually by the Executive Committee. Vacancies in the list of officers occurring during the year shall be filled by appointment by the Executive Committee.

SECTION 3. The Treasurer shall perform the duties required under Section 4, Article X, of the American Water Works Association.

ARTICLE VI

Meetings

SECTION 1. The meetings shall be held annually at such time as shall be ordered by the Executive Committee. The place of meeting shall be the University of Iowa, Iowa City, Iowa, unless otherwise ordered by the Executive Committee.

SECTION 2. Special meetings may be called by the Executive Committee or upon written request of fifteen members of the Section.

SECTION 3. Ten members shall constitute a quorum for the transaction of business.

ARTICLE VII

Constitution of the American Water Works Association

The Constitution and By-Laws of the American Water Works Association, to the extent to which they are applicable, shall govern the transaction of the business of the Iowa Section, but no rules or by-laws of this section shall be inconsistent with the Constitution and By-Laws of the American Water Works Association.

ARTICLE VIII

Amendments

The Constitution may be amended by a two-thirds vote of the members present and voting at any annual meeting of the Section. Such amendment shall be in effect after approval by the Executive Committee of the American Water Works Association.

The application of the Iowa members to form a section was approved by the Executive Committee of the American Water Works Association and the constitution of the new section was also approved by the Executive Committee.

CENTRAL STATES SECTION

CINCINNATI, OHIO, May 10, 1915.

To Executive Committee American Water Works Association.

Gentlemen: The undersigned Active or Corporate Members of the Central States Water Works Association residing in the territory below named respectfully request authority to form a local section of the American Water Works Association.

The territory to be included in this Section to be as follows: Southern Michigan, Ohio, West Virginia, Kentucky, and Pennsylvania west of and including McKean, Elk, Clearfield, Blair and Bedford counties, Pennsylvania.

We submit herewith a copy of the Constitution and by-Laws for the government of the proposed section for your approval:

F. W. COLLINS	S. F. MESSER	R. P. BRICKER
W. C. DAVISSON	WILLIAM FLEIG	GEORGE J. FISHER
F. B. LEOPOLD	E. FORD	H. J. PUTNAM
L. A. TONKEL	JAMES WILKINSON	ROY A. HOBBS
CHARLES BENNETT	W. J. SCROGGINS	W. C. MESSER
W. C. WILES	WILLIAM JUNKINS	J. C. MARTIN
A. W. INMAN	W. F. SCHICKLER	C. J. SMITH
A. W. CARPENTER	M. J. BREECE	WILLIAM BRUCK

CONSTITUTION AND BY-LAWS OF THE CENTRAL STATES
SECTION OF THE AMERICAN WATER WORKS
ASSOCIATION

ARTICLE I

This Association shall be known as the "Central States Section of the American Water Works Association" succeeding the "Central States Water Works Association."

ARTICLE II

The object of this organization shall be the same as that of the American Water Works Association, namely "The advancement of knowledge of the design, construction, operation and management of water works, and the encouragement, by social intercourse among its members, of a friendly exchange of information and experience."

ARTICLE III

The headquarters of the Section shall be at such place as may be designated by the Executive Committee of said Section.

ARTICLE IV

The membership shall consist of the members of the American Water Works Association residing in the following territory: Southern Michigan, Ohio, West Virginia, Kentucky, and Pennsylvania west of and including McKean, Elk, Clearfield, Blair and Bedford counties.

ARTICLE V

SECTION 1. The officers of the Section shall be Chairman, Vice-Chairman, Secretary, Treasurer, and four Trustees, who shall perform the duties usually incumbent upon such officers. These officers shall constitute an Executive Committee. These officers except the Trustees shall hold office for one year, the Trustees for two years, but upon the first election subsequent to the adoption of this Constitution two Trustees to be elected for one year and two for two years, and thereafter two to be elected annually to serve for two years, or until their successors are elected and qualified. Vacancies in the list of officers may be filled by the Executive Committee.

SECTION 2. At least thirty days before each annual meeting of the Section, the Secretary shall mail to each active, corporate, or honorary member a blank upon which the member may express his choice for Chairman, Vice-Chairman, Treasurer and two Trustees. The Secretary, in conjunction with two other members appointed by the Chairman, shall count all nominating ballots before the date of the annual meeting. The three members who shall have received the greatest number of nominating ballots for each office shall be voted on by ballot by the members present at the annual meeting. The Secretary shall be appointed by the Executive Committee.

SECTION 3. The Treasurer shall submit all bills to the Chairman of the Section before payment and shall perform the duties required under Section IV, Article X, of the Constitution of the American Water Works Association, as follows: "Each Local Section may receive from the Treasurer of the Association, for local use, not more than 25 per cent of the annual dues paid to the Association by the members of said Local Section. The Treasurer of said Local Section shall forward to the Secretary of the Association his application indorsed by the presiding officer of the Section for such portion of said sum as may be needed; and upon receipt of such application the Secretary shall request the Finance Committee to authorize the Treasurer of the Association to pay such sum to the Treasurer of the Local Section. Said sum may be used by the Local Section only in the payment of necessary operating expenses incurred by the Section, such as printing, stationery, postage, rent and care of room, light, fuel, etc. At the end of each fiscal year the Treasurer of each Local Section shall certify to the Secretary of the Association the balance on hand of the funds from the Association. This balance shall be returned to the Association or shall be charged to the Local Section as a portion of its quota for the following year. The Local Section shall not be entitled to draw upon the Association until such certification has been made and its accounts audited by the Finance Committee.

SECTION 4. Twenty members shall constitute a quorum for the transaction of business.

SECTION 5. At the regular meetings of the Section the business shall be conducted in the following order:

Reading of minutes; reports of officers; reports of committees; miscellaneous business; announcements; reading of papers and discussion; adjournment.

ARTICLE VI

SECTION 1. The meetings shall be held annually at time and place as designated by the members present at previous annual meeting, but the Executive Committee shall have power to change the place of meeting, if in their judgment it seems desirable to do so, provided that such action be taken by unanimous vote of the Executive Committee.

SECTION 2. Special meetings may be called by the Executive Committee or upon written request of twenty-five members in good standing. In case of such a special meeting the object shall be definitely stated and no other business shall be transacted.

ARTICLE VII

No rules or by-laws of this Section shall be inconsistent with the Constitution and By-laws of the American Water Works Association.

ARTICLE VIII

The Constitution and By-laws may be amended by a two-thirds vote of those present and entitled to vote at any regular meeting of the Section provided twenty-four hours' notice shall have been given in convention by not less than five members in good standing. Such amendments shall be in effect after approval by the Executive Committee of the American Water Works Association.

The application of the members of the Central States Water Works Association to form a section of the American Water Works Association was approved by the Executive Committee of the American Water Works Association and the constitution proposed for the government of the section was approved.

CHEMICAL AND BACTERIOLOGICAL SECTION

FIRST SESSION

Thursday Morning, May 13, 1915

The first session of the Chemical and Bacteriological Section was held at 9.30 a.m., Thursday, May 13, 1915, at the Hotel Gibson, Cincinnati, Ohio, Mr. W. F. Monfort, presiding. There were about fifty members present.

CHAIRMAN MONFORT: The meeting will come to order. We will listen to the minutes of the last meeting.

SECRETARY KIENLE: The meeting of the Chemical and Bacteriological Section was held at the Bellevue-Stratford at the last session

of the American Water Works Association Convention held at Philadelphia, May 14. Resumé of the previous meeting at Minneapolis was read. The Secretary stated the work done during the year, followed by statements from Professors Bartow and Monfort of the objects of the Section.

There was some discussion of the separate meeting question—that is to say, holding the separate meeting independent of the main body of the Association; also the by-laws of the Section.

After that a motion was offered by Mr. Bartow, that the Chairman or Secretary ask the Executive Committee of the main organization to set aside one day at the next convention for the holding of an independent Section Meeting. This motion was passed.

The question of by-laws for the Section was discussed but no definite action was taken.

A motion was carried for the election of a committee to act as the Executive Committee of the Section for the ensuing year, also to prepare by-laws for the Section.

The following named were nominated and elected as such committee, viz: Wilson F. Monfort, Francis D. West, M. B. Litch, S. T. Powell and John A. Kienle.

The election of officers of the Chemical and Bacteriological Section resulted as follows:

President: Mr. M. B. Litch, Superintendent and Chemist Filtration Plant, Steelton, Pa.; Secretary: Mr. John A. Kienle, 25 Madison Avenue, New York City; Executive Committee: Mr. Paul Hansen, Engineer State Water Survey, Urbana, Ill.; Dr. Wade H. Frost, U. S. Public Health Service, Cincinnati, O.; Mr. Charles P. Hoover, Chemist Filtration Plant, Columbus, Ohio.

DISCUSSION

MAINTENANCE OF THE WATER SUPPLY DISTRIBUTION SYSTEM OF NEW YORK CITY¹

MR. FRED B. NELSON: The scope of the subject which Mr. Brush has covered necessarily forbids his taking up in detail any one of the small divisions of the many that make up the total mainte-

¹ A paper by Mr. William W. Brush read at the meeting of the New York Section of the American Water Works Association, December 3, 1914, and published in Vol. 2, No. 1 of the JOURNAL of the Association at p. 206, etc.

nance work of the New York Water Department. It may therefore be that a few features of the underground waste detection work bearing directly upon the subject of maintenance may be of interest, principal reference being given to the Boroughs of Manhattan and the Bronx, which consume roughly two-thirds of the 500,000,000 gallons per day supplied to the greater city, also the development and continuance of a large leakage is especially favored in these two Boroughs by sub-surface conditions. The original rock surface in Manhattan and the Bronx has been blasted out for street grading, basements of buildings, sub-way construction, etc., and much of the excavated loose rock used as fill in bringing low areas up to grade. Many of the sewers are in rock excavation and street mains and service pipes are frequently laid in the sewer trenches.

The saving in the two Boroughs has in the past four years totalled 33,000,000 gallons per day, which includes some 217 individual leaks, the size of which range in gallons per day as follows:

Ten leaks were from 500,000 to 4,000,000 g.p.d. and averaged 1.4 million gallons per day.

Forty-six or 21 per cent were from 100,000 to 500,000 g.p.d. averaging 200,000 g.p.d. and 161 or 75 per cent were below 100,000 g.p.d. and averaged 60,000 gallons.

As to the nature of the leaks they may be classified as follows:

		<i>per cent</i>
Service leaks.....	84	39.0
Blown or leaking joints in mains.....	66	30.0
Abandoned services.....	28	13.0
Broken mains.....	15	6.9
Valves and hydrants leaking underground.....	13	6.0
River crossings.....	5	2.3
Open blow offs.....	3	1.4
Sand Holes (so called).....	3	1.4
	217	100.0

The value and urgency of waste detection work are largely subject to conditions of supply. During the threatened water shortage of 1911, waste detection work was considered of great value irrespective of the service, i.e., whether pumped or gravity. Later, with the danger of water shortage eliminated and the ample Catskill supply near at hand, the value of waste detection work in the low or gravity service was considered of lesser value and underground waste detection work

was confined principally to the pumped services where the cost of pumping and the capacity of the stations were involved. During 1911 the special plumbing inspection and repairs resulted in a saving of about 12 per cent of the total consumption within a very few months as determined by pitometer gaugings of the total consumption made before and after the inspection in 17 districts covering the greater portion of Manhattan Island. On the other hand with underground leaks it is impossible to secure any great saving without extensive investigations, requiring considerable time. A saving, however, due to repairing of underground leaks may be considered of far greater permanence. It has been found that the leakage stopped by special plumbing inspection and repair will again develop in from two to four years, while it may readily be assumed that underground repairs to service pipes, blown joints, abandoned services, broken mains, etc., would leave the system as good or better at those points than the original construction and that the saving of water secured is practically permanent. It has also been found that in Manhattan and Bronx a large proportion of the leaks find a channel through the loose rock and soil to sewers or other outlets and may continue indefinitely without being found.

During 1913, 56 underground leaks were located and repaired, totalling 5,390,000 g.p.d. None of these leaks was apparent from surface indications, and assuming that on the average they would have continued for two years only, before being found and repaired through complaints, damages, etc., the total cost of the work was \$3.55 per million gallons. During 1914, 64 leaks were located and repaired, totalling 11,000,000 g.p.d. of which one-half or 5,500,000 g.p.d. was included in two large leaks. Estimating the cost by the same method as above considering only the 5,500,000 gallons, comprising 62 of the 64 leaks, the cost would be \$3.24 per million gallons. On the assumption that these leaks would otherwise have continued for 10 years the cost would of course be reduced in inverse proportion to about 70 cents per million gallons.

This underground waste detection work is entirely aside from the regular repair work as carried on by the repair gangs, which work is concerned principally with leaks which have already made themselves manifest or are causing complaints. The force mentioned by Mr. Brush employed in the search for leaks which are not apparent from surface indications or from complaints received is

employed very largely on determination of hydraulic gradients and pressure studies in connection with new mains and reinforcement of the system, measurement of flow in trunk mains measurements of consumption in large sections of the distribution system, etc. The time which this force spends at present on underground waste detection proper would be equal to about one-third time. Systematic searches for leaks are carried on in areas where consumption is found to be high and are usually taken up by means of pitometer gaugings showing ratio of minimum night rate to the total consumption followed by the usual subdivision of the district to localize waste; these results being followed up by aquaphone soundings, inspection of sewers, service pipes, etc., for final location. Leak locating is otherwise called for in emergencies where the damage is such as to require prompt location of the break and also investigations are started due to indications obtained in connection with other work. In nearly all cases it has been found that by the methods employed with a generous admixture of study and detective work by the engineer in charge leaks can be uncovered and repaired on an average with but one or two street openings. Thus in 1914 the 64 leaks previously mentioned required 80 street openings, an average of $1\frac{1}{4}$ openings for each leak. During the severe weather conditions in January and February of that year one gang of laborers was given aquaphones and allowed to cover an area in which it was desirable to reduce leakage. The competition between the men resulted in a considerable list of "noisy" hydrants, gate valves, etc., which were individually followed up in more favorable weather with a careful investigation by the assistant engineer in charge of the gang, with a view of uncovering the leaks with the least possible number of street openings, and as a result 22 leaks totalling 1,400,000 g.p.d. were located and repaired with but 27 street openings. In general, considering the cost of the work, it is not thought to be profitable in New York City to search for leaks smaller than from 25,000 to 30,000 g.p.d. unless there is some definite indication of their location, or damages are being caused thereby. The latter reason has often called for long drawn out and discouraging work, but in general with gratifying final results; as an instance, it recently became necessary to locate a leak amounting to only 100 to 200 g.p.d. By house to house aquaphone tests of plumbing the leak was found in the basement of a dwelling on an

adjacent street, one street opening having been made in the course of the search, to disconnect and make a positive test of the service pipe of the house which the water was entering.

On various occasions special methods have been used where conditions have suggested them. The ratio of pressure loss between two points when supplying the leak between them from alternate directions may sometimes be used. In one instance the leak from a small main on a down grade was located by means of a shut-out with a sensitive gauge connected at the foot of the hill, the pressure dropping steadily until the gradient or water level at the leak was reached. The pressure then remaining constant indicated the elevation of the point of leakage on the main above the gauge elevation, and the leak was uncovered with one street opening at the point determined. Hydraulic gradients may be used to advantage when the leakage is large in comparison to the capacity of the main.

A combination of gradient and aquaphone methods was recently used in locating a break in about 3000 to 4000 feet of 12-inch sub-marine main. Valves were so closed as to supply the leak from one direction through a long line of 12-inch on the main land. Levels were run and the distance measured between two hydrants on this line, and simultaneous pressures taken on the hydrants with accurate gauges. The slope of the hydraulic gradient in feet per thousand feet was thus obtained. Levels and simultaneous pressures were then taken on hydrants at either end of the broken submerged main. Assuming of course that the gradient would be level from the dead end back to the point of the break, the difference in gradient elevation at the two hydrants divided by the gradient slope determined on the main land gave the approximate distance of the break from the hydrant on the supply end. This approximate location was followed up by aquaphone tests, made from the bow of a launch. The launch cruising as nearly as possible along the location of the main was stopped at various points where the aquaphone was used on an oar with the blade immersed in the water. The leak sound was distinctly picked up and the location of greatest intensity of sound selected and fixed by means of stadia rod on the boat and a transit on land to be about 600 feet out. The diver in repairing the leak was instructed accordingly, and found the break within about 100 feet of the distance calculated.

*DISCUSSION*THE YONKERS WATER SUPPLY AND ITS FUTURE DEVELOPMENT¹

MR. EDWARD WEGMAN: Mr. Fulton has pointed out the difficulties which Yonkers encounters in trying to increase its water supply. The sources which would be suitable for this purpose have been acquired by the City of New York, and Yonkers is, therefore, obliged either to buy the additional quantity of water it requires from New York at a high price, or to go to a considerable distance for a new supply. Under these circumstances there was nothing left for Yonkers to do but to develop its present sources of water supply to their utmost limit, and to trust that, in the course of time, a Metropolitan Water Board, similar to the one of Boston, Mass., will be created to take charge of the water supply of New York and of the near-by towns and cities.

The manner in which Yonkers intends to increase its present supply has been described fully by Mr. Fulton, and leaves little room for discussion. The only feature of the proposed work which involves difficult construction is the proposed earthen dam, which is to raise the high water level of the Grassy Sprain Reservoir forty feet. This dam is to be built about 350 feet down-stream from the present dike, and will have a length of about 1070 feet, and a width on top of 24 feet.

The dam will have a height of about 90 feet above the surface, which will place it among the high earthen dams of America. Most engineers will agree that it is more difficult to construct a high dam of earth than of masonry. With the latter material, a leak through the dam causes usually only a loss of water; while with the former material, a leak may lead to the failure of the dam. In order to prevent undermining, an earthen dam should be provided with a masonry or puddle core-wall, which should be carried down to an impervious stratum.

At the site selected for the Yonkers dam, rock lies at a distance of about 90 feet below the brook, and as the rock valley is wide, there is a large quantity of material overlying the rock. This

¹ A paper by Mr. D. F. Fulton, read at the meeting of the New York Section of the American Water Works Association, December 3, 1914, and printed in Vol. 2, No. 1, of the JOURNAL of the Association at p. 1, etc.

material is sand of varying degrees of coarseness, and much of it is so coarse that water flows freely through it.

It would be very expensive to dig a foundation trench to rock for a core-wall through such material. Mr. Fulton states that it has been suggested to obtain a cut-off for the dam "either by driving steel sheet piling to rock, or, in the deeper part of the valley, by sinking a connected series of caissons and filling them with grout or concrete." If the material overlying the rock were uniform, that might possibly be done. But the speaker is told that this material is a glacial drift, containing more or less boulders. It is very doubtful whether steel sheet piles could be driven 90 feet deep through such material, so as to make a practically water-tight cut-off. If caissons were sunk, this work would not only be very expensive, but would involve much difficulty in getting the caissons down vertically to rock, so as to make a tight cut-off. Quicksand or a sliding of the sand, would deflect a caisson from the desired position. At the Hauser Lake Dam, caissons for a coffer-dam were sunk to a depth of 70 feet, but that was through water. It would evidently be more difficult to sink a caisson through sand, quicksand and boulders to a depth of 90 feet.

In drawing attention to the difficulties that will doubtless be encountered in constructing the proposed dam across the Grassy Sprain, at the site selected, the speaker does not wish to imply that this work is impossible, but it will be very expensive and if it is not done properly, may lead to the failure of the dam. The present Grassy Sprain Reservoir has been formed by an earthen dam constructed on similar ground as that at the site of the proposed dam; but it stores only about 50 feet of water, and when the depth of water at the dam is raised to nearly 90 feet, undermining of the dam may occur, which would not take place with the lower head.

Many failures of earthen dams have occurred, even when these works were built by good engineers. The terrible disaster caused by the rupture of the Johnstown Dam in Pennsylvania is the worst case of this kind that has occurred in America. This dam was 70 feet high. It was ruptured by water flowing over its top, after an unusually heavy rainfall. In England one of the most notable failures of an earthen dam is that of the Dale Dyke Dam, which was constructed for the Sheffield Water Works. This structure was 95 feet high by 1254 feet long. It was 12 feet wide on top and about 500 feet wide at the bottom. Both slopes were made $2\frac{1}{2}$ to 1. In

the investigations that took place, after the rupture of the dam, the greatest engineers of England testified as experts, but their opinions as regards what started the failure, varied very much, and this question was never finally settled.

DISCUSSION

A SPECIAL WATER STANDARD¹

MR. JOSEPH RACE: The chief interest to the speaker in this paper lies in the standards adopted for the maximum limits of impurity to be permitted in water supplied by common carriers engaged in interstate commerce. This standard is divided into two clauses, first—bacteria capable of development on agar at blood heat and secondly—a B. Coli limit. Whilst the latter will probably meet with general approval undoubtedly the former will be the object of severe criticism both on account of the general method and the numerical limit. It is very much to be regretted that the Commission has repeated the mistake of the Water Committee of the American Public Health Association in adopting the agar count at 37°C. as many bacteriologists are now convinced of its general weakness. Without going into the “pros” and “cons” it is sufficient to say that the bacteria counted by this method in many cases are derived from sources that have no connection with matter that may be infective. Whilst the speaker has not had occasion to examine many samples of the water supplies of carriers the general experience with waters of this class has been that the bacterial count on agar is too largely influenced by bacterial multiplication during transportation to have any real value. A low count is of course generally indicative of satisfactory conditions, but a high count, on the other hand, should not “per se” condemn the sample. Those who have had experience in the examination of such waters can usually distinguish between plates showing a large count due to original contamination and excessive counts due to bacterial development but it is practically impossible to express this difference numerically or to standardize it.

The only advantage of this standard, in the opinion of the speaker, is that it practically compels the provision of *fresh* water although this is evidently not the intention of the Commission for they state

¹ A paper by Mr. Wilson F. Monfort published in the JOURNAL OF THE AMERICAN WATER WORKS ASSOCIATION, Vol. 2, No. 1, at pp. 65, etc.

that very liberal limits were allowed so as to discount multiplication of the bacteria.

As a rapid method for the enumeration of organisms of faecal origin I have for some years employed neutral red bile salt agar (rebipelagar) in 150 mm. plates with 10 cc. of sample. Such plates are examined after 20 to 24 hours incubation and the number and size of the red colonies noted. Small colonies are due to attenuated organisms and such colonies may be found on the plate although the lactose bile tubes remain negative.

The results obtained by this method vary in the same direction as the confirmatory lactose bile tube method adopted by the Commission, but, as they also include some attenuated organisms, the numerical results are higher.

The differentiation of attenuated and virile organisms is an advantage rather than otherwise as it affords valuable evidence of the past history of the supply in addition to its present condition.

The speaker also likes to see Rebipelagar used as an alternative to litmus lactose agar and Endo's medium in the confirmation of *B. Coli* on account of the facility of preparation and technique. In laboratories where large numbers of water samples are examined daily it is of considerable advantage to facilitate media preparation and examination technique as far as possible when consistent with accuracy.

The general principles involved in the confirmatory methods for *B. Coli* as suggested by the Commission, are excellent and should be adopted for all water supplies.

DISCUSSION

THE ACQUISITION OF PRIVATE WATER PLANTS BY MUNICIPALITIES¹

MR. EDWARD WEGMAN: Mr. Wagner has made a careful study of the subject of valuations of the plants of private water companies. While he has no new theories to advance, he reviews in his paper the whole subject of valuations. The tables, giving important court decisions about water works valuations, and the bibliography appended to the paper will be very useful to engineers and water works superintendents, who are called upon to make estimates of the value of the plants of private water companies.

¹ A paper by Mr. B. M. Wagner, printed in Vol. 2, No. 1, JOURNAL OF THE AMERICAN WATER WORKS ASSOCIATION at pp. 25, etc.

DISCUSSION

DRY FEED OF CHEMICALS IN WATER PURIFICATION¹

MR. WILSON F. MONFORT: The organism referred to in this paper (page 204-5) is one on the border line between algae and bacteria. It is the *Chlamydothrix ochracea* of Migula, called *Leptothrix* by Kütz- ing and *Streptothrix* by Cohn. Among the synonyms mentioned by Wolle are *Lyngbya* (Thur.), *Conferva* (Dill.), *Oscillatoria* (Crev.). The branched form is represented by Dillwyn, and Wolle figures it thus in one plate, with the remark "so are most of our specimens." Chester (Man. of Det. Bacteriology) prefers *Cladothrix ochracea*, following Winogradsky.

The organism is easily grown in a 5 to 10 per cent solution of ferrous sulphate; within a few days the growth on a submerged slide shows characteristic development with false branching. It stains with aniline gentian violet, which renders easy observation of false branching, conidia, and the formation of the gelatinous sheath on older specimens.

As observed first the iron tank in which it occurred was tufted over with a growth up to three inches long, which was broken off by the dash of the inflowing solution.

Some experiments to ascertain the source of the infection indicate that the organism develops in sterile distilled water in which is dissolved ferrous sulphate as it arrives in cars lined with building paper. Whether it was originally derived from water used in preparing the sulphate of iron, or from the building paper was not determined.

The most remarkable fact about this species is its ability to grow in a solution of ferrous sulphate, and in any concentration up to saturation. The stoppage of pipes by this growth has been observed in several purification plants. The remedy lies in reducing to a minimum the length of pipes conveying such a solution, and the avoidance of orifices for regulating the volume of solution applied. Dry feeding offers the best way out of the difficulty.

MR. J. W. ELLMS: We have found organisms of the type of which Mr. Monfort speaks at the Cincinnati Filter Plant. Although we

¹ A paper by Mr. Wilson F. Monfort published in Vol. 2, No. 1, of the JOURNAL OF THE AMERICAN WATER WORKS ASSOCIATION, at pp. 200, etc.

have been unable to find the branched forms, the organisms that we did observe certainly belonged to the class which include *Leptothrix* and *Crenothrix*.

The organisms observed by us were found in the sulphate of iron solution tanks in the sludge attached to the sides of the tank. This sludge or deposit is of the same character as that found in our iron sulphate solution pipe lines. We have always had more or less trouble from the partial stoppage of these pipe lines by this deposit. Until Mr. Monfort called attention to these organisms, which will grow in a sulphate of iron solution, the speaker had always attributed the difficulty primarily to the ferric hydroxide produced by the oxidation of the ferrous iron by the oxygen dissolved in the water used in preparing the solution. Our chemical solution pipe lines are very long, and contain a good many elbows. The first pipe lines used were of cast iron and $3\frac{1}{2}$ inches in diameter. On account of the low head available for forcing the solution through these lines, even slight obstructions would cut down materially the rate of flow. A new pipe line 5 inches in diameter was installed, but the trouble still continues, although the stoppages are less frequent.

Mr. Monfort's discovery offers a possible explanation of these stoppages which would never have occurred to the speaker. We have found that stoppages were more frequent during the winter months or when the water was at a low temperature. During the hot months, little trouble has been experienced. We have found that flushing these pipe lines under pressure with cold water is often ineffective. Driving steam and hot water through the pipes seem to clear them more effectively than does cold water.

Our laboratory observations of the growth and appearance of these organisms confirm those of Mr. Monfort, excepting those relating to the branched forms. All filter plant operators using sulphate of iron solutions would do well to investigate their pipe lines and tanks in order to learn whether like conditions prevail in their own plants.

*DISCUSSION*EXAMINATION OF DRINKING WATER ON RAILWAY
TRAINS

MR. FREDERICK H. STOVER: Will Dr. Bartow please state if these new standards apply to steamers on inland lakes and rivers, and whether they would apply to excursion steamers between local points? Many of these steamers take their supply from the nearest sources, very often from the stream on which they run. Can anything be done to standardize the water supply on them?

DR. EDWARD BARTOW: Any interstate carrier, whether by rail or by water, would be controlled by these standards, they are being used for steamers on the Great Lakes, and probably on river steamers too.

MR. FREDERICK H. STOVER: From one part of a state to another?

DR. EDWARD BARTOW: Yes. Would not want to give that as authentic.

¹ A paper by Prof. Edward Bartow, published in the JOURNAL OF THE AMERICAN WATER WORKS ASSOCIATION, Vol. 2, No. 1, at pp. 74, etc.

STUDIES OF ARTESIAN WATERS IN CHICAGO AND SURROUNDING TERRITORY

BY CARL B. ANDERSON AND F. W. DEWOLF

INTRODUCTION

The rapid decrease in the artesian water supply of Chicago and the surrounding region was brought to the attention of the State Geological Survey in 1912, and arrangements were made to coöperate with the State Water Survey in a careful investigation. The field and laboratory work is now finished and a preliminary statement of some of the striking features is presented to the Illinois section. The following items relating to the Chicago area are considered briefly: underground water supply; water-bearing formations; artesian conditions; lowering of water table, and chemical quality of waters. Plate I illustrates the area concerned, and shows the variation in water table by means of 10-foot contours.

UNDERGROUND WATER SUPPLY

Northeastern Illinois has an underground water supply of great value to cities and small towns, and to industrial demands, in view of the fact that the streams are small and their waters are of poor quality.

Underground water is obtained from three kinds of wells: shallow wells in the surface formations, shallow rock wells, and deep rock wells which are artesian in character.

The first two groups are large producers of water only in isolated cases where the sand and gravel are very thick, and the rock is shallow and very porous. The deep wells, however, are generally available as a source of water. Many large industries in Chicago, which require large amounts of water at a low cost, have drawn heavily on these underground water resources.

WATER-BEARING FORMATIONS

Surface deposits. The surface water-bearing beds include unconsolidated sand, clay and gravel deposited directly or indirectly by the glaciers, and also the sand deposited in a larger lake, which preceded Lake Michigan. The constituent materials vary greatly both in size and character. The thickness around Chicago ranges from a very thin coating to over 100 feet.

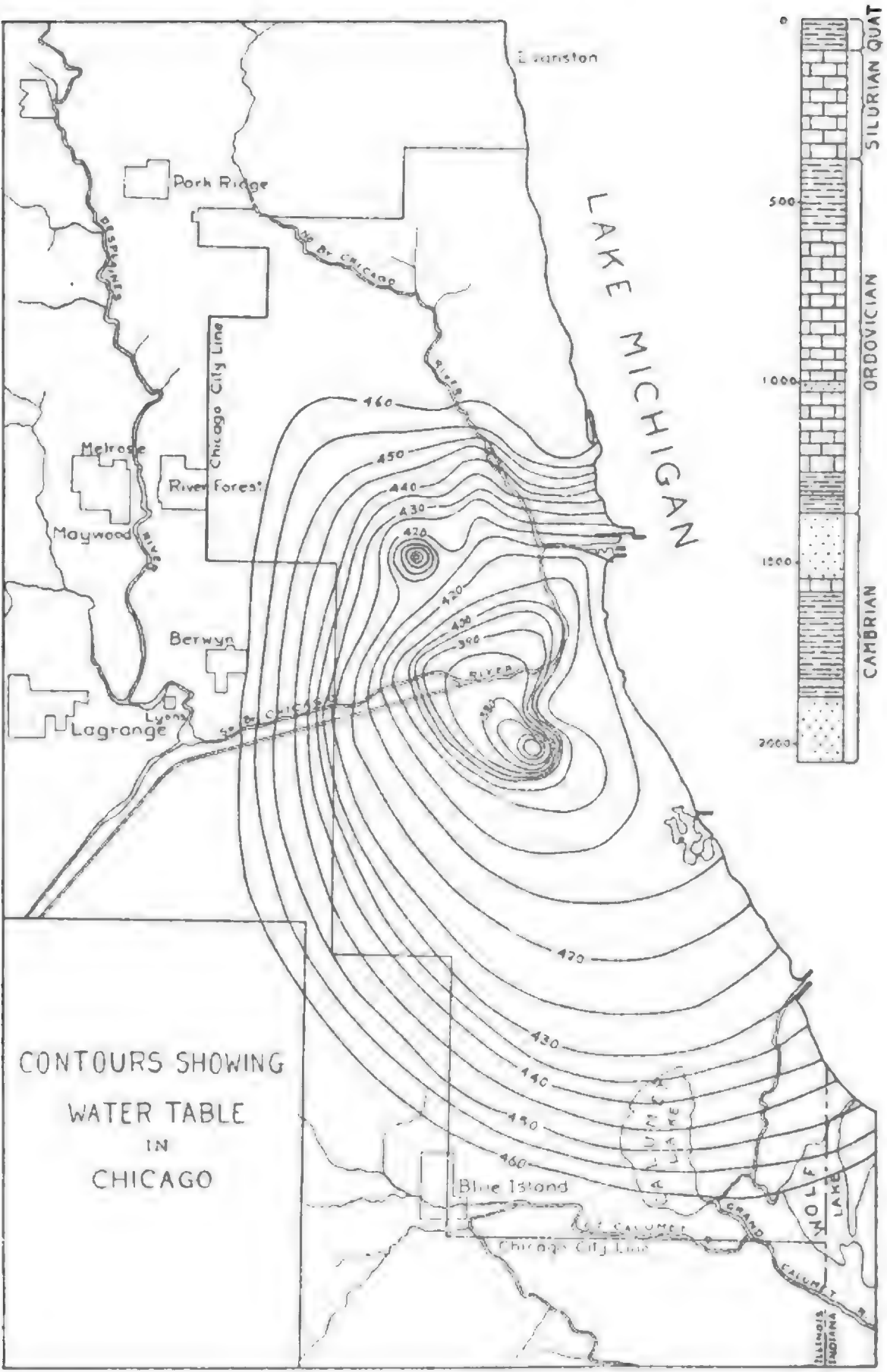
Wherever the surface materials are as thick as 100 or more feet, plenty of water can generally be obtained for domestic purposes, for small factories, or even for municipalities.

The only hard rock that outcrops at the surface is the Niagara limestone or "bed rock," which can be seen in many quarries in the vicinity of Chicago. The thickness varies between 150 and 300 feet, averaging about 250 feet. Locally, the Niagara contains considerable water, due to the presence of fissures and to a thick layer of porous drift which receives the rainfall. Such a belt extends north and south through Hinsdale, Illinois, and finally swings eastward and passes through Chicago Heights. Both of these cities obtain large amounts of good water from shallow rock wells.

Deep water supplies. The deeper formations underlying Northeastern Illinois are shown in Plate II. The Niagara is from 200 to 300 feet in thickness and is underlain by the fine-grained Maquoketa shale which is practically impervious to water. Other beds call for special mention:

Galena-Trenton limestone. The Galena-Trenton is a light gray, fine-grained dolomite or limestone which contains considerable magnesium carbonate. Fragments of chert nodules and a small amount of rounded quartz grains have also been found in the well drillings. The thickness varies from 300 to 450 feet. The first flow of water obtained in Chicago was from the Galena-Trenton limestone at a depth of 711 feet. The water rose to 80 feet above the surface or 111 feet above Lake Michigan.

St. Peter sandstone. The St. Peter sandstone formerly furnished great amounts of artesian water in Chicago. The thickness varies abruptly from 20 feet to over 250 feet, and the well driller may even report finding no sandstone at this horizon. The St. Peter sand was deposited on a very uneven surface of the Lower Magnesian limestone, which thus accounts for its great variation in thickness. The St. Peter is composed of a remarkably pure, well-rounded, siliceous sand.



The drilling of a large number of wells to the St. Peter sandstone resulted in an extremely heavy drain on these underground water resources. There were still flowing wells from this bed in Chicago during the early '90's, but at present it is impossible to obtain sufficient quantity of water from this formation for industrial purposes.

Lower Magnesian limestone. The Lower Magnesian lies next below the St. Peter sandstone. It is considerably fractured at a certain horizon about 1200 feet below the surface, and contains water in these fissures. The deep well at the Western Electric Company's plant, during the summer of 1912 was tested at this horizon, and yielded slightly over 200 gallons per minute without the water level being lowered over 10 feet.

Potsdam sandstone. The Potsdam sandstone generally means the first, heavy, sandstone member of the Potsdam series, sometimes called the Madison sandstone. It is found in Chicago at a depth of 1350 to 1400 feet. The first 100 feet is usually light brown, and is followed by 100 feet of a cream-colored sandstone. Below the Madison there is a somewhat sandy and shaly dolomitic limestone for another 200 feet. Underlying this limestone, other heavy beds of light brown, red, buff, or white sandstone, alternate with thin beds of dolomite and shale. The sand as a rule is coarser and not as well rounded as that of the St. Peter formation.

The Potsdam rocks are the oldest penetrated in the Chicago region and are known to a depth of at least 1000 feet.

The chief interest attaches to the Potsdam because it yields by far the greatest amount of artesian water used in the Chicago area. The main water-bearing stratum is the Madison, which wherever penetrated by a well of sufficient size, yields 300 and more gallons of water per minute.

ARTESIAN CONDITIONS

The term "artesian well" is applied to one whose original source of water is at a considerable distance, whether the well flows or not. This water has collected from rainfall in an area rather remote from the well, and has traveled under hydrostatic pressure through a porous bed until tapped at a point lower than the source.

The porous formations in this region are: the sandstones of the Potsdam series, the St. Peter sandstone, and to some extent the Lower Magnesian limestone. The Potsdam and the St. Peter are

the main water-bearing strata. They rise to the north and outcrop in south-central Wisconsin, at an altitude higher than that at Chicago.

The relatively impervious beds lying above the water-bearing formations prevent the escape of the waters until tapped by drilling. The overlying beds need not be entirely impervious provided they are filled with water, so that the downward pressure of the water is as great as the upward pressure of the water contained in the lower formations.

LOWERING OF WATER TABLE OF DEEP WELLS

Historical. The first artesian well was drilled in Chicago in 1864 at the corner of Chicago and Western avenues, and yielded a strong flow of water from the Galena-Trenton limestone at a depth of 711 feet. The water rose to 80 feet above the surface or 111 feet above Lake Michigan.

There were still flowing wells from the St. Peter in Chicago during the early '90's.

Since that time, with the increase in the number of wells drilled, there has been a gradual loss of hydrostatic pressure, even though the wells have been drilled deeper. At present all wells that furnish large quantities of water penetrate the Potsdam series. The water level has been lowered from 80 feet above the surface, so that now it is 220 feet below the surface when at rest, or 235 feet when pumping, in the stock yards district, where a large number of wells operate in a small area.

The greatest decline has been in the past 5 years during which time more large wells have been drilled than during any previous 5-year period.

A map with 10-foot contour interval has been prepared for the city of Chicago, showing the artesian water table as it was in October, 1914. The figures on contours indicate elevations above sea level. The hydrostatic pressure rises rapidly after leaving the stock yards, and then more gradually towards the outer parts of the city.

Effects of pumping. During the summer of 1914, when the greatest amount of water was being pumped in the stock yards district, the water level would fall to 232 feet below the surface. This would affect the area within a radius of one-half mile, even though certain wells would be idle. The lowest water level of 235 feet was measured in a large well pumping over 1500 gallons per minute. Meas-

urements obtained on many wells in this district showed that immediately after cessation of pumping there would be a gradual rise of about a foot in the first hour, and beyond that time no noticeable rise, even though the well was shut down for a number of hours. This was the case when the other wells in the stock yards were pumping to capacity. Measurements made, however, on a Sunday afternoon when only about half as much water was being pumped as on week days, showed a water level of 212 feet below surface, and indicated a rise of 20 feet.

Another example of the effect of pumping so large an amount of water was shown in a new well located about one-half mile from the group of largest wells. This well showed little water until the St. Peter sandstone was penetrated at about 900 feet, when the water rose to the general water level of the stock yards district. The St. Peter formation over other parts of Chicago no longer furnishes much water. The water from this new well was analyzed and found to be of the same character as that obtained from the deeper sands by other wells in this district. Thus it appears that the water from the Potsdam formations rises and enters the St. Peter sandstone, because of lack of casing in neighboring wells.

MINERAL CONTENT OF WATERS

The water obtained from the large producing wells in Chicago is a very hard, sulphate water, with mineral matter varying from 60 to over 100 grains per gallon. Wells deeper than 1800 feet encounter salt water, thus increasing the total mineral content to a very high amount. The water is primarily used for condensing and cleaning purposes.

Detailed analyses made by the State Water Survey of water from typical wells were presented in a paper last year by Mr. Anderson.

THE APPLICATION OF THE THEORIES OF PUBLIC REGULATION TO THE MANAGEMENT OF UTILITIES

BY DOUGLAS A. GRAHAM

Regulation or control of public utilities must do justice to both the public and the utility or it cannot endure. Much has been said and written concerning the rights and interests of the people, and, in some cases at least, statements have been made with so small an understanding of the object of just utility regulation as to make it appear that the rights of the people are in jeopardy and that the authors of these statements are advocates in the case of "The People versus the Corporations."

This condition of affairs is not and should not be the case. The contention of the utilities in demanding fair returns is based on the provisions of our national constitution which refer to property rights, and, while the people have the right to demand efficient service in return for the privileges granted by them, they must be prepared to pay for what they receive. In other words the interests of both parties can best be served by devising fair and simple means of providing a fair return to the utilities in return for adequate service furnished to the public.

Millions of dollars are invested in public utility properties, and, when such money is devoted to the public use, the public must feel its responsibility toward such capital and must treat it with wisdom and justice.

FUNDAMENTAL PRINCIPLES

The fundamental requirements of just regulation may be stated under three headings.

1. To provide a fair return on the investment at all times.
2. To protect the capital invested so that it may remain intact or ultimately be returned to the investor.
3. To promote efficient management and to require adequate and satisfactory service.

Much has been written about the theories of regulation and there is little real difference in opinion among men who have knowledge of these matters. Less has been said and done to devise means for putting these accepted theories into practice and still less attention has been given to helping the utility operator to understand and apply these principles to his own particular property.

The movement toward public regulation by commission has spread rapidly of late years and, in general, it has been welcomed by both the utilities and the people. Unfortunately the subject of just and practical regulation is a difficult and complicated one and the rapid growth of the movement toward state control has created a demand for more men skilled in these matters than the profession has been able to supply. It may almost be said that the movement toward public regulation has grown more rapidly than the knowledge on the subject itself, and the result has been that commissioners have been forced, in many cases, to solve their problems as they have arisen, often without the aid of those especially trained in the work. Unfortunately this lack of preparedness and the newness of the field has sometimes led to an exaggeration of the value of precedent, and many opinions, methods and rules, inspired in the past by the necessity of arriving at some conclusion, have been perpetuated, simply because "precedent" furnished the necessary semblance of authority.

Nothing is further from the mind of the writer than that he should presume to criticise or question the ability or fairness of any of the men who are entrusted with the solution of the important problems of utility regulation. The errors that have been made, if they may be termed as such, are not errors of intent or lack of skill. They are due to the magnitude and newness of the problem, to the lack of special training in many of the men engaged in the work, and to the fact that few of the men so engaged have learned by experience the viewpoint of the utility.

It has been well said that no engineer, however skillful, is competent to appraise a utility plant until he has been employed by both a utility and by a city, as only in this way can he understand the viewpoint of each in such a manner as to do justice to both in his future work. Regulating bodies are employed by the people and are constantly in danger of being suspected of favoring the corporations, and it is only by a strict judicial impartiality and an earnest endeavor to understand the viewpoint of both parties that a regulating body can do justice to both the public and the owners of the utilities.

It is earnestly hoped, therefore, that the spirit of antagonism between the people and the utilities may give place to a spirit of mutual endeavor to obtain efficient service for just compensation, and that the governing bodies will give careful attention to the claims of the utilities and solve the contended problems, not on the precedent in the case, which may have been set by lesser minds than theirs, but upon a full knowledge and understanding of the facts and a fearless adherence to logic and justice.

It is not the intention of this paper to discuss or to attempt to substantiate the fundamental theories mentioned above. It is rather the application of these theories to the management of a utility that the writer has in mind, and it is hoped that some of the suggestions offered will bring out discussion and perhaps aid in the adoption of simple and fair methods which can be easily understood and applied by the utility manager. When such rules are worked out uniform systems of accounting may be adopted and the labor of supervision and regulation will be materially reduced.

CAPITAL ACCOUNTS

The first step in preparing for public regulation or, in fact, in preparing for the intelligent supervision of a property for any purpose, is to determine its value. This can rarely be done from past construction accounts owing to the appreciations and depreciations which have taken place and to the usual inaccurate or incomplete condition of these accounts. In most cases an appraisal of the property is necessary and such an appraisal should be authoritative, and, if possible, it should be concurred in by the body by which the utility is to be regulated.

After the present value of the property is determined, the old capital and depreciation accounts may be reconciled with the new value. The total value of the property may then be subdivided in accordance with the details of the appraisal and the requirements of intelligent supervision. New detailed construction accounts may then be opened and future construction charged at cost.

All materials and labor for new construction should, of course, be charged to these accounts in the future. There are some other items, however, which may properly be mentioned as their inclusion in construction accounts has been the subject of some discussion.

Discount of bonds sold for construction seems unquestionably to

be a proper charge against the construction accounts of a growing utility. There has been much discussion of this subject in connection with the valuation of an entire property, where interest during construction, going value, preliminary costs and the like are to be computed. It is not the intention of the writer to discuss this phase of the subject or to admit that there is any difference between the two cases, but in an operating utility, where money must be raised by selling bonds, the cost of selling these bonds must be paid just as surely as the cost of labor and material. If \$90 worth of construction is to be undertaken and the bond discount is 10 per cent, then \$100 worth of bonds must be issued and redeemed in cash at par upon the expiration of their terms. Ultimately, therefore, the utility must pay the bond discount in cash and the cash cost of the new construction must be charged to the assets of the company as \$100.

Overhead costs are often neglected in charging construction to the books because of the difficulty of determining their amount. The overheads on a small extension may be insignificant, but, when a number of extensions have been made, the total of the overhead costs may amount to a considerable sum.

During the construction season the manager or superintendent devotes part of his time to the construction work, and a charge to construction should be made for such time. Automobiles may be used partly for construction purposes and, therefore, a part of their operating costs and depreciation should go to capital accounts. There is interest lost before new construction is completed and its fixed charges can be carried in operating accounts, and there are costs for business investigations and negotiations, in connection with new construction, which are not properly a part of the operating charges. Engineering, of course, must go in with the cost of the structure for which it is procured, but, as this is usually a separate account, it is easily charged directly, and is, therefore, not a part of the indefinite overhead costs to which this article directly refers.

Such costs, and others not specifically mentioned, are a real part of construction costs and should be charged as such. The amount of these charges is, however, a difficult matter to determine in the average plant. It is possible to so divide the charges and the time of all employees as to obtain an accurate distribution of all overhead costs, but such a system would involve so much labor, and such skilled accountants, that it is beyond the reach of the average sized

utility. Perhaps the best solution of the difficulty, and one which may be made fair to all concerned, is to determine an average percentage to be charged to all construction work and to be based on the cost of the material and labor items that can be easily determined.

The amount of this percentage may vary with the size of the plant, and it will be materially affected by the number of indefinite items which it is possible to charge directly to the construction accounts. In plants in cities of 20,000 to 30,000 a 10 per cent charge will probably be reasonable, although such a percentage must not be adopted without a thorough knowledge of the items which it is intended to cover. Also, all items should be charged direct as far as it is practicable to do so and the amount of the percentage for overheads thereby reduced to a minimum.

Operating capital is sometimes lost sight of in fixing rates, though it is as much a part of the capital devoted to the public as is the money invested in machinery. Operating capital may be defined as "that capital which is not invested in permanent structures or apparatus, but which is necessary for the operation of the business and which cannot be withdrawn or used for other purposes." It includes cash in the bank or in any other form in which it may be used upon demand, and also the capital temporarily invested in tools, supplies and the like. Such money is devoted to the business and it can receive no return unless it is included in the value upon which a fair return is to be computed. It should, however, be kept separate from the fixed or construction capital as it is variable and its depreciation should be treated separately.

Operating capital must not be confused with capital invested in non-operating property, such as lands bought in advance of their actual need. The writer believes that, in valuing a plant, no distinction should be made between operating and non-operating property, unless it can be clearly shown that the investment in property, not actually "used and useful" for the service of the public, was not made in the sole interest of the utility plant.

If property is non-operative because of obsolescence or poor condition, its value should be reduced or perhaps totally removed by means of the depreciation placed upon it, care being taken to consider all of the uses, both present and future, to which that particular property might be adapted. If the property is a piece of land, bought in anticipation of the needs of the plant, it should be considered that the management acted in good faith, unless the re-

verse can be clearly proven. To exclude such land because it is not now actually in use, is to discourage the utility from anticipating and providing for the future needs of the plant.

The object of keeping detailed construction accounts is to be able to consider intelligently costs of construction and operation. The division of these accounts should, therefore, conform to the units of a property for which cost data are commonly available. For example, the important general divisions of a water works plant are the water supply, the purification plant, the pumping station, the distribution system and one or more divisions for general costs, applying to the entire plant, such as overhead costs and going value. Land should be subdivided and charged with the division to which each part belongs. Other general subdivisions may be made, if necessary, to suit the requirements of each particular plant. The available costs of filtration are mostly in the form of construction costs per million gallons daily plant capacity, and operating costs per million gallons filtered, and one must know the value of the filter plant as a unit in order to compare its value with that of other plants, or to figure the element of fixed charges in finding the total unit cost of purification.

The subdivision of the main construction account headings will vary considerably in several plants and must be suited to the needs of each. In general it may be said that the classification should be based on the estimated lives of the various parts of the plant. While it is not intended to prescribe a definite form for the classification of construction accounts, the following arrangement is offered merely as an illustration of the principles discussed above:

CLASSIFICATION OF CONSTRUCTION ACCOUNTS

Intangible capital

- Organization and preliminary costs
- Going value

Water supply capital

- Lands
- Well houses and equipment
- Miscellaneous equipment

Purification capital

- Lands
- Buildings
- Filters
- Pumps
- Blower and motors

Purification capital—Continued

Miscellaneous equipment

Upper storage basin

Lower storage basin

Pumping station capital

Lands

Main buildings and stack

Miscellaneous outbuildings

Boilers and breeching

Feed pumps and boiler accessories

Pumping machinery

Electrical machinery

Miscellaneous equipment

Ground improvements and switch track

Distribution system capital

Cast iron pipe mains and valves

Hydrants

Pavement over C. I. pipe mains

Wrought iron pipe mains and valves

Pavement over W. I. pipe mains

Service connections

Meters

*Overhead construction capital*Interest, administration, superintendence and miscellaneous costs @ 10
per cent of material and labor cost

Legal expense.

Injuries and damages

Insurance

Discount or commission on construction bonds

Operating capital

Cash on hand

Stores and supplies

Tools and appliances

A very convenient summarized construction account book for a small plant, may be made from an ordinary column-ruled book which can be purchased at a stationery store. The general headings and subdivisions may be written at the top of each page and the accounts opened with the details from the appraisal, a column at the right being used for totals. The item may be described at the left and the total cost entered in the proper column. Such a book would give an up to date classified record of the value of the plant and would be very valuable in making annual reports.

DEPRECIATION

The treatment of depreciation and the computation of the amounts of the annual charges for this item, are among the most difficult of the problems with which the utility manager is confronted. In the competitive commercial world the depreciation account is purely a matter of business policy, but where a utility is under public control, and the obligations of the public and the corporation are mutual, depreciation is no longer a matter of policy but becomes subject to the laws which govern the fixing of a fair return.

The presumption in fixing rates is that the utility shall earn a fair return on the value of its property, and in addition an amount annually which will be sufficient to make good the depreciation losses. It is generally conceded that an allowance should be made for depreciation in the revenues, but the manner of computing this allowance and of treating it in the book accounts is still the subject of much discussion and difference of opinion.

The allowance for annual depreciation must cover future losses only, as the courts have held that a utility cannot make charges in the future to compensate for losses in the past. It is this principle which makes it essential that the depreciation allowance be actually received before it is deducted from the capital, for an allowance on paper only is misleading and is of no practical benefit to the utility. The question of the actual receipt of the depreciation allowance will be considered more fully under the heading of Fair Return, and the following discussion will assume that the depreciation allowance is to be actually received.

The first and perhaps the most important question to be decided, in determining the manner in which the depreciation allowance shall be treated, is whether it shall become a part of a replacement fund, out of which replacements or renewals will be made, or whether it shall be considered as a partial repayment, by the public to the utility owners, of the capital devoted to the public use. The principles involved are the same in each case as by either plan the investment is maintained intact. The former plan is familiar to the general public but it has many drawbacks. The latter plan, which appears to have many advantages, was suggested by a special committee of the American Society of Civil Engineers in their recent report on "Valuation for Rate Making Purposes."

The replacement fund method involves the estimation of the

depreciation of all of the details of a plant and an accurate distinction between that part of a new structure which is a replacement and that which is an improvement. An old machine is never replaced by a new one of exactly the same size and kind. There is always some improvement. A replacement fund is made up of annual increments which will replace each part of the plant as its life comes to an end. When a new machine is installed it is necessary, therefore, to take part of its cost from the replacement fund and part must be paid with new capital. If the life of the old machine has been accurately estimated, this is not a very difficult proceeding, but if this life has not been exactly predicted, the provision for amortizing the value of the old machine is either insufficient or more than enough and it is a difficult matter to determine just what part of the new cost shall be taken from the replacement fund. In short the accurate maintenance of a replacement fund requires a system of accounting beyond the reach of most utility companies, and, unless such a system is faithfully carried out, the replacement fund loses much of its merit and becomes largely a matter of guess work.

In the repayment method, as its name suggests, the depreciation allowance is considered as a repayment of the invested capital, to be deducted from the capital account and used as new capital. The merit of this plan is its simplicity as, when the amount is fixed by careful appraisal, it is handled as a lump sum and no tedious details are necessary. All replacements or additions are charged in full to capital accounts and the annual depreciation allowances are deducted from the plant value. The results obtained with this plan are the same as those with the replacement fund, as, in each case, if all worn-out structures were to be replaced with identical new ones, the construction account would always remain the same. The difference between the two methods is one of accounting only, but the simplicity gained by the treatment of depreciation as a lump sum repayment of capital is worth much to the utility manager.

There are three plans which have been devised for computing the amount of the annual depreciation allowance. These are the sinking fund, the straight line and the equal-annual-payment plans. All three require an estimate of the present value of the plant and its composite remaining life.

The sinking fund method is familiar to all. The annual allowance is the increment to a sinking fund which will retire the investment

at the end of its life. This method requires the creation of an actual sinking fund for replacements as its interest additions each year must come from the investment of the fund. Few companies care to carry an actual sinking fund on account of the low interest rates which can be earned by such a fund. Also there are serious accounting difficulties which arise when the working of the sinking fund principle is disturbed by the removal of money for replacement purposes and by the constant changes in the composite life of the plant, due to additions and alterations. It is believed that in practice the theoretical working of a replacement fund on the sinking fund principle can only be approximated at best, and the difficulties involved are quite enough to discourage the ordinary utility manager.

The straight line method of computing the annual depreciation allowance commends itself by its simplicity. Under this plan the total physical value of the plant is divided by the number of remaining years of the composite life of the property and the result is the annual depreciation charge. It has two serious objections, both due to the fact that its amount is the same from the beginning to the end of the plant life.

Experience shows that actual depreciation is small during the early years of the life of a plant and that it increases rapidly during the later years of operation. The sinking fund method is designed to approximate the working of this law but the straight line method produces results which are too great during the early years and too small during the later years of the life of a plant. Also the straight line allowance bears no relation to the probable income which a plant will receive. It imposes too heavy a burden during the early years of development and it is too small during the later years when the income is more fully developed. This method, therefore, while simple in operation, is absolutely arbitrary and is not well suited to the requirements of a public utility.

There is another method, also suggested by the committee of the American Society of Civil Engineers which has been referred to above. It has been called by it the equal-annual-payment plan, and takes its name from the fact that by its use, at any given interest rate and considering no additions to the plant, the total of the depreciation allowance and the fair return is the same each year during the life of the plant. If plant additions are considered, the constant amount of the depreciation plus fair return changes to a constant percentage of the total plant value.

The equal-annual-payment or E-A-P plan is, in fact, a modified sinking fund in which the interest accretions are added directly to the annual charge instead of being earned by the fund itself. This plan eliminates the complications of the sinking fund while preserving its advantages, and seems to offer a satisfactory solution of the problem.

The following table illustrates the working of the rule as applied to a given set of assumptions.

Example of working of E-A-P depreciation rule

Assumptions: Initial investment \$100. Additions \$5 per year. Average life of original plant 20 years; life of each addition 20 years

AGE, YEARS	FULL INVESTMENT AT END OF YEAR	DEPRECIATION DURING YEAR (5 PER CENT RATE)	NET VALUE END OF YEAR	5 PER CENT ON NET VALUE	DEPRECIATION PLUS RETURN	PER CENT OF INVESTMENT PAID BY PUBLIC IN FAIR RETURN AND DEPRECIATION ALLOW- ANCE
	\$100.00	\$3.02	\$100.00	\$5.00	8.02	8.02
1.....	105.00	3.32	101.98	5.10	8.42	8.02
2.....	110.00	3.64	103.66	5.18	8.82	8.02
3.....	115.00	3.97	105.02	5.25	9.22	8.02
4.....	120.00	4.32	106.05	5.30	9.62	8.02
5.....	125.00	4.69	106.73	5.34	10.03	8.02
6.....	130.00	5.07	107.04	5.35	10.42	8.02
7.....	135.00	5.48	106.97	5.35	10.83	8.02
8.....	140.00	5.90	106.49	5.32	11.22	8.02
9.....	145.00	6.35	105.59	5.28	11.63	8.02
10.....	150.00	6.82	104.24	5.21	12.03	8.02
11.....	155.00	7.31	102.42	5.12	12.43	8.02
12.....	160.00	7.82	100.11	5.01	12.83	8.02
13.....	165.00	8.37	97.29	4.86	13.23	8.02
14.....	170.00	8.94	93.92	4.70	13.64	8.02
15.....	175.00	9.53	89.98	4.50	14.03	8.02
16.....	180.00	10.16	85.45	4.27	14.43	8.02
17.....	185.00	10.82	80.29	4.01	14.83	8.02
18.....	190.00	11.51	74.47	3.72	15.23	8.02
19.....	195.00	12.24	67.96	3.40	15.64	8.02
20.....	200.00	13.00	60.72	3.04	16.04	8.02

The resulting total charge for fair return and depreciation is a constant per cent on the full investment at the end of each year.

The rule for finding the depreciation each year under this method is as follows: Find the remaining life of the plant, which would

be say 45 years, and decide on the sinking fund interest rate to be used, say 4 per cent. Find the annual increment to a 4 per cent 45 year sinking fund, which would be 0.8262 and which would be the charge for the first year. The second and succeeding years the allowance would be the charge for the previous year, plus 4 per cent of that charge, plus 0.8262 per cent of the increase in plant value during the preceding year.

The following table gives the factors for finding the first year's depreciation allowance, computed at four different sinking fund interest rates.

E-A-P depreciation factors

REMAINING COMPOSITE LIFE OF PLANT	FACTOR IN PER CENT FOR FIRST YEAR			
	4% rate	5% rate	6% rate	7% rate
5 years.....	18.4627	18.0975	17.7396	17.3891
10 years.....	8.3291	7.9505	7.5868	7.2377
15 years.....	4.9941	4.6342	4.2963	3.9795
20 years.....	3.3582	3.0243	2.7185	2.4393
25 years.....	2.4012	2.0953	1.8227	1.5811
30 years.....	1.7830	1.5051	1.2649	1.0586
35 years.....	1.3577	1.1072	0.8974	0.7234
40 years.....	1.0524	0.8287	0.6462	0.5009
45 years.....	0.8262	0.6262	0.4700	0.3500
50 years.....	0.6550	0.4770	0.3444	0.2460
60 years.....	0.4202	0.2828	0.1876	0.1229

The simplicity of the E-A-P plan, the nearly constant relation of its annual increment plus the fair return to the changing value of the plant, the percentage being only constant when the same interest rate is used in computing both depreciation and fair return, and the growth of its annual increment with the development of the business of the company, recommend it very highly for use in the management of a utility property.

Few utilities in this part of the country have carried depreciation accounts until the last few years and, where such accounts have been kept in the past, they have often been little more than memoranda. The amounts charged have usually been variable and not in accordance with any definite rule or principle and, as far as practical benefit to the utility is concerned, such accounts might just as well have never been created. The growing tendency toward

public control has inspired the opening of many depreciation accounts and the newness of the problem of public control, combined with lack of knowledge of plant values, has been largely responsible for the haphazard manner in which depreciation accounts have been treated in the past.

The writer believes that the most important factor in determining the proper treatment of depreciation in the operating accounts is the amount of depreciation the property is actually permitted to earn. This bears directly upon the much debated question of whether or not the depreciation allowance should be deducted from capital. Under the well accepted theory that a utility is entitled to receive a fair return and to be permitted to maintain its property value intact, it is obviously unfair to deduct depreciation from capital if such depreciation allowance is not actually earned in addition to a fair return. Also, if money is actually provided for depreciation, it must either be put back into the property by means of replacements without increasing the capital accounts, or it must be deducted from capital accounts and be considered as invested capital which has been returned or repaid by the public.

The writer makes no pretenses of being an accountant, and he is familiar only from general knowledge with the requirements of a plan of utility accounts. His experience and association with those engaged in this work, however, have taught him some of the difficulties to be avoided and the objects to be achieved. It is believed that the choice of methods for handling annual depreciation lies between the replacement fund and repayment plans described above, and, on account of the almost insurmountable difficulties in the way of the practical fulfillment of the replacement principle, it is believed that the depreciation should be treated as a repayment of the invested capital.

In planning the accounts on the repayment plan depreciation may be charged directly to profit and loss and credited to construction, or it may be carried through a separate depreciation account. The cash repayment may be charged to general cash and credited to a special cash account from which it is to be used as new capital. Other similar combinations will produce the same results. No detailed estimate of depreciation is necessary as all new and replacement capital is charged in full to construction.

In computing the annual depreciation charge, as explained above, operating capital may well be excluded. The depreciation on tools

and construction appliances should be added to the construction accounts. Depreciation on very short lived property used in the operation of the plant may properly be charged as operating expenses direct.

There are certain contingent depreciations which occur occasionally during the life of every plant. A fire may cause unexpected damage or an accident may destroy some of the machinery. A runaway may break a hydrant or a main may burst. Such unexpected depreciation is sure to occur at some time, and an allowance should be made for it in the annual charge for depreciation.

FAIR RETURN

The principles governing the operation of public utilities are pretty well understood, and it is conceded that a property is entitled to fair earnings on its investment in return for efficient service to the public. The application of these principles is quite another matter and the results obtained in the past have not been altogether satisfactory. Fairly definite estimates may be made of operating expenses, but the consumption of the various classes of consumers, the future increase in their number and the changes in plant value, are matters so indefinite as to make it extremely difficult to fix rates which will furnish exactly a fair return on the property.

In a growing city, an increase in business must be expected, and it is probable that such growth in income will exceed the increase in operating expenses, fixed charges and fair dividends. Rates cannot be revised each year and it is easily seen, therefore, that the problem of providing a fair return at all times is a difficult one.

In the past, under municipal control, regulation has too often meant a reduction of rates whenever the opportunity offered itself, and the temptation to use the issue of reduced rates as political capital has often proved too strong. The arguments for rate reductions have nearly always included estimates of future prosperity, and rates have often been fixed on the theory that future increases would make up for present losses. Unfortunately, in such cases, when the future increases have taken place administrations have changed or memories have failed and the realization of the hopes of the utility for a fair return have once more been consigned to the future.

It is often difficult for the layman to understand the hardships

and losses attending the early years of the operation of a public utility. He sees only the present and future and he is guided more by the size of his own bills and by the campaign speeches of the city politicians than by any knowledge of the task involved in the construction and development of such a business.

Under such a system of political regulation in the past the utility business has too often been a gamble with the other fellow fixing the odds. In our own and many other states this system is happily in vogue no longer, and it is to be hoped that the new era of sound regulation upon which we are entering will bring out new methods of providing a fair return which will do away with some of the hazards which have attended on such business in the past.

As explained before it is the practice of regulation, rather than the theories involved, that is still the subject of debate. It is conceded that a utility should receive a fair return, but theories and concessions will not pay bond interest, dividends and depreciation. It is the problem of how actually to obtain a fair return at all times that is of vital interest to the utility manager. The public expects efficient service at all times and transgressions on the part of the company are not easily forgotten. In fairness, then, provisions should be made that will permit the company to enjoy a fair return at all times.

A simple way to accomplish this result may be termed the trust fund method. It contemplates the creation of a trust fund to which all profits would be carried and from which the utility would be allowed to withdraw a fair return each year. Such a plan would accomplish all the results desired by both parties. If the fund should grow too fast, rates could be reduced and if it were found to be insufficient, rates could be increased. By this plan the uncertainty would be removed from future estimates and the wisdom of a new schedule of rates could safely be left to the decision of a trial, without jeopardizing the interests of the public or of the corporation.

A general custom in business management is to charge all profit to a surplus account from which dividends are paid. This surplus, then, might well be used as the trust fund suggested. It would receive all profits above operating expenses and depreciation, and would be drawn upon to the amount of a fair return each year. Such a fund would be under the control of the regulating body and could be properly accounted for.

The operation of the trust fund plan would be simple. With

the books reconciled to an approved valuation and continued with actual costs, with readjustments at infrequent periods when necessary; with the depreciation allowance treated as a repayment of capital on the equal-annual-payment plan; and with the operating and other accounts under the supervision of the accountants of the regulating board; this plan seems to solve the problem of actually providing the return which is awarded to the utility.

EFFICIENT MANAGEMENT

Equally important with the actual providing of a fair return is the enforcement of efficient and satisfactory service. As the weakness of past systems of regulation has been in the failure to actually provide a fair return, so the fundamental weakness in past requirements for good service has been the lack of incentive given the utility to improve its service. Standards of purity of water, pressure and the like should vary somewhat in different cities and a regulating commission can prescribe limits, more or less definite, to apply to each particular case. In matters of economy, however, the task of supervising the operation of all of the utilities in a state is too great for any organization so far established. Refinements in economy are suggested only to those operating a property or to those making a special study of the plant in question. It is to the utility manager, therefore, that we must look for material improvements in efficiency and, to enlist his efforts, an incentive must be provided.

In competitive business the standard for plant improvement is economy. If an old machine can be replaced by a new and more modern one, at a saving in annual cost fixed charges and depreciation included, good business dictates that the improvement shall be made, as by so doing the net earnings of the business will be increased. Consider now the position of the utility manager in such a case when his plant is operating under the present accepted methods of public control. The commission probably does not know that the old machine can be profitably discarded, so the change would be voluntary on the part of the company. Rates have been fixed on the basis of present plant value and operating expenses, and the utility is getting a fair return. If the manager discards the old machine he must furnish capital for the new one, and it may be that there has been an insufficient allowance for the depreciation of the old one. His assets, therefore, are likely to be reduced by the

change and his only reward for his trouble and expense is a decrease in operating expenses and a consequent increase in earnings. If the regulating body had allowed him 7 per cent return he may have increased this to $7\frac{1}{4}$ per cent by increasing his plant efficiency. But the commission has only allowed him a 7 per cent return and his efforts have, therefore, entitled the public to a reduction in the rates which, when accomplished, will leave the utility where it began.

Another phase of the same difficulty is the effect of developing the business. In general, the larger the amount of business done by a utility per capita of population the lower the rates may be to produce a fair return. Public welfare, therefore, dictates that the utility business of each community should be fully developed, both for the reason just mentioned and also because the prosperity of a community bears a close relation to the efficiency and widespread use of its public utilities. Yet, on the fixed-percentage-of-return system of regulation, the enterprising manager who, by skill and labor, builds up the business of his company gains no advantage over his brother in the next city whose business has been less fully developed.

It is obvious, therefore, that the common practice of awarding a fixed percentage of fair return takes away from a utility manager all incentive for improving his property, except that which may be furnished by his pride in his own plant or by the orders of the governing board on matters which come to their attention.

The only practical solution of this problem is to put a premium on efficiency by giving the utility a share in the results of its labors. If improvements in a plant produce savings, both the public and the utility should benefit. The saving to the public can be cared for by reducing rates and the share to which the utility is entitled can, perhaps, best be provided by varying the percentage of fair return allowed.

In the application of the method of a graduated-fair-return, the normal fair rates must first be fixed for the particular plant under consideration. The utility would then be permitted to earn an increased percentage of fair return only on condition that rates be lowered below the normal. To illustrate, let us assume a water works plant for which a 7 per cent fair return has been provided, by means of a sliding scale of rates varying from 10 cents to 30 cents per thousand gallons. The application of the variable return principle would then permit the utility to earn a $7\frac{1}{4}$ per cent return,

when they had given the consumers a discount of 5 per cent on their bills; and 8 per cent return when the consumer's discount reached 10 per cent and so on. These figures are used purely for illustration and the writer does not know if they even approximate the scale which should be adopted. The proper scale can only be found by careful study, but the principle seems to be right and it appears to be practical of application. It is earnestly hoped that efforts will be made to adopt some such plan as this in order to overcome the fatal lack of incentive for increased economy which is inherent in the present systems of utility regulation and which is opposed to the interests of both the public and the corporations.

Another thought, which comes in connection with the question of a graduated fair return, is the possibility of adopting standard rates throughout the entire district controlled by one regulating body. This suggestion is offered merely for discussion by those interested, but seems to the writer to merit more consideration than might at first appear. A public utility is a business and it is, therefore, only reasonable that business acumen in the selection of a desirable field of operations should receive some reward. The tendency of most of the methods of regulation seems to be to put all utilities alike on the basis of property value without regard for the cost of the service furnished.

Utility properties differ widely in desirability from the standpoint of cost of production. Some water works plants must filter their water and pump it twice; others must pump from a lake or well without filtration, and still others have water delivered to them under pressure, from flowing wells or springs. With competition, in the same locality, the plant whose cost of production is high would be driven out of business. Under a system of fair return on property value, however, no distinction is made between plants whose cost of production differs on account of the characteristics of the community. The wisdom of this policy is open to question as the utility is not called upon to share any of the burden of high cost of production, where such is found, nor is it permitted to benefit by the low rates, where the cost of production is low.

The solution of this problem seems to be the consideration of the effect on fair rates of the value of the service to the consumer, and the adoption of standard or normal rates, combined with a graduated fair return, might be the answer to the question. In the application of this principle, the city favored by conditions which

promote economical production would enjoy low rates and these, in turn, would increase the percentage of fair return to which the utility would be entitled. In a city where production cost is high the reverse would be true, and in both cases the utility and the public would share in the hazards and profits of the business.

It is believed that this plan merits careful consideration and the writer hopes that the suggestion will bring out discussion on the subject. It is probable that distinctions would need to be made between cities of different sizes and perhaps in other ways, but even a partial standardization of rates would simplify the work of the regulating board and would permit an intelligent comparison of rates in adjacent cities.

CONCLUSION

The subject of this paper is a broad one and the questions involved are large and difficult. The discussion of these problems has been lengthy and it may not be amiss to emphasize, by a brief summary, the more important suggestions which the writer desires to present for consideration.

1. Capital accounts should show the true value of the property and this value should preferably be approved by the body by which the utility is to be controlled.

2. The depreciation allowance should be considered as a repayment of the capital invested, all new construction and replacements being charged in full to capital, and the annual allowance being deducted from capital accounts and used in any way in which the company is permitted to use capital. The amount of the annual allowance should be figured on the equal-annual-payment-plan.

3. Provision should be made so that a utility will actually receive the fair return and depreciation allowance which is awarded to it. This may perhaps best be accomplished by regarding the surplus as a trust fund out of which the utility will be paid the earnings to which it is entitled.

4. Incentive for economical management should be provided, in addition to the well accepted requirements of satisfactory service. This can be accomplished by providing for a fair return percentage which will vary with the change in the costs of service to the consumer. This principle may perhaps be developed still further by the adoption of standard normal rates throughout an entire

state or district, so that both public and corporation may share in the advantages or disadvantages of the utility business in each community.

5. The treatment of all of the problems involved in regulation is intimately connected with the provisions to be made for assuring the utility that it will actually receive the returns which are awarded it, and the problems of determining the earnings for a utility and of actually providing them must be considered together.

In the forgoing discussion the writer has had the water utilities more particularly in mind, although most of the principles involved are applicable to all publicly controlled enterprises. It is hoped that the suggestions offered will be freely discussed and that the future may bring a better understanding and application of the theories of just utility regulation, to the mutual benefit of both the public and the utility corporations.

SOME FEATURES OF THE ONTARIO STATUTES AND THEIR ADMINISTRATION AFFECTING WATER SUPPLIES AND SEWERAGE SYSTEMS.¹

F. A. DALLYN, C.E., B.A.Sc.²

It is the writer's pleasure and privilege as a Canadian and a member of this association to report progress in the province of Ontario. In reading this paper it is hoped to convey to the association not only some idea of the excellence of the existing statutes in Ontario, but a short summary of the history and development of the clauses affecting water supplies and sewerage systems.

Practically all legislation which places municipal enterprises under control of government commissions is of recent enactment. This is also true of legislation relegating the control of water works and sewerage installations to federal, state or provincial health bodies.

In 1873 there existed no central organization for the administration of public health regulations in Ontario. The authority at that time was vested almost entirely in the members of the municipal councils, who by virtue of their office became health officers. The act relegating authority to the municipal councils would not in this day be considered at all complete. One of the typical sections of that act reads:

Any two of these officers shall have the right to enter into and upon the premises in the day time for the purpose of examination to see whether they were in an unclean or filthy state.

They had power to order the proprietor or occupant of the premises to remedy the condition; they could also order persons suffering from contagious diseases to be removed to some hospital, when the medical practitioner reported that this could be effected without danger to the health of the patient. There was apparently no regulation whatever respecting water supply or sewerage, although there existed at that time in the municipal act a clause giving power

¹ Paper delivered before the Illinois Section of the American Water Works Association March 10, 1915.

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to a council to pass by-laws, for preventing the wasting and fouling of public water, and for regulating the construction and drainage of cellars, sinks, water closets, privies and privy vaults.

The Provincial Board of Health of Ontario was not created until 1882 and from that date until 1911 the control of the Local Boards of Health was vested in this central body. This body had a secretary with offices in the Parliament buildings. He had a good deal of executive power, but all plans, etc., relating to water and sewage were left to the board, and decided at the quarterly meetings.

The Municipal Water Works Act of 1882 gave to municipalities rather wide powers. (1) Providing for the control of streams acting as sources of municipal water supplies within a distance of one mile, in the cases of villages or towns, and three miles in the case of a city. (2) Prohibiting the draining of sewage or extraneous matter that would in any way taint or foul the source of a water supply. There is no mention of water purification works in this act, efforts being directed mainly toward exclusion of pollution. Strangely enough no mention of this matter appears in the Public Health Act of that date. The passing of this act in 1882 coincides very well with the period when so much was talked of about the self-purification of streams. Bacteriology at this date was a very young science.

In 1884 the Public Health Act was further amended and provided that:

Whenever the establishment of a public water-supply or a system of sewerage should be contemplated by the council of a municipality it shall be the duty of the said municipality to place itself in communication with the Provincial Board of Health and to submit all plans in connection with said system to the board.

The board was authorized to enquire into and report upon the plans; copies of this report being forwarded to the municipal council and also filed with the government. This act also contained a general clause which required that:

No sewer or by-laws for extending the same shall be constructed in violation of any of the principles laid down by the Provincial Board of Health and subject to appeal to the Lieutenant-Governor-in-Council.

It seems rather strange to think that as recently as 1886 such an indifferent character of legislation could exist, although research

assures one that the information existing at this date upon the subject of epidemiology and the control of the pollution of streams was largely a blank as far as useful knowledge was concerned.

The executive health officers of the various municipalities met and formed an association. The activities of this body, which was largely controlled through the Provincial Board of Health, materially influenced the advance of sanitary science. Perhaps the greatest advantage at this time was the manner in which their deliberations included citations of European efforts, especially those of the Rivers Pollution Commission and the Local Government Board, who were doing a splendid work in advancing legislation and publishing information along these lines. In considering the amendments of this period one must remember that very little exact information was forthcoming until the reports from the Lawrence Experimental Station were issued in 1891, 1892, and 1893 and these for several years remained largely in the hands of the laboratory workers.

In 1895 the act was further amended, and required municipalities to furnish, together with the plans of the proposed works, an analysis of the water from the proposed source. The analysis was a chemical one and the water was reported upon largely according to old albuminoid standards. The act recited that "where the Provincial Board reported against the supply it should not be lawful to establish such works." The jurisdiction of the board was increased; the board was now permitted to suggest changes in connection with the plans submitted and its decision became binding subject to appeal to the Lieutenant-Governor-in-Council.

It was not until 1906 that the act was amended and a clause inserted making it unlawful to discharge sewage, drainage, domestic or factory waste, excrement or other polluting matter of any kind whatsoever, which either by itself or in connection with other matter corrupts or impairs the quality of any water supply. A penalty under the act was set at \$100 for each conviction and each week's continuance after notice was set out as constituting a separate offence.

The most forward step of the legislature was taken in 1911 when it was enacted that the chief health officer, who was also the secretary, should be the executive officer of the board and at intervals between meetings of the board should perform such duties and acts and have such powers as are by the act vested in the Provincial Board of Health. To those of you who are interested in the adminis-

tration of legislation such an amendment can be seen to be of the utmost advantage. Applications from municipalities can now be considered as soon as received instead of being held some times for several months for a quarterly meeting of the board. The act was further reinforced and a section added reciting:

That no by-law shall be passed for the raising of money for water and sewerage purposes until the proposed water supply or sewerage system, as the case may be, has been approved by the Provincial Board of Health, and such approval has been certified to and signed by the chairman and secretary of the board.

It provided that the preamble of the by-law should recite such approval.

During 1911 and 1912 the Public Health Act was carefully revised, drawn by Mr. John W. S. McCullough, M.D., D.P.H., the present chief officer of health, and was passed by the legislature in 1912. One important amendment stands out and provides that

96.—(1) Where the Provincial Board reports in writing that it is of opinion that it is necessary in the interest of the public health that a water works system or an adequate water purification plant, or a sewer or a sewerage system, or an adequate sewage treatment plant, should be established or continued, or that any existing water works system, water purification plant, sewer or sewerage system, or sewage treatment plant, should be improved, extended, enlarged, altered, renewed or replaced, it shall not be necessary to obtain the assent of the electors to any by-law for incurring a debt for any of such purposes.

A further clause was added to the act requiring municipalities to make reports to the board of such information as may be required by it, on forms to be furnished by the board. This clause was especially arranged to apply to both water works and sewerage. The wording of the clause respecting submission of plans was slightly altered and made to apply to extensions of existing systems as well as to new systems.

In 1914 the act was further modified to permit with the approval of the Provincial Board of Health the sewage disposal system of a municipality to be continued into or through or to be situate in any adjoining township municipality. The act provides that before approving of such work the Provincial Board of Health shall give notice to the clerk of the township that such application has been made, and shall hear all objections before granting approval. After the approval has been granted the municipality receiving such ap-

proval is permitted to expropriate and arbitrate the value of the lands the same as if the work had been situate within the limit of the municipality. An interpretation of this clause indicates that damage by reason of the location of the works will not be allowed.

The Ontario Railway and Municipal Board is a body which is empowered by the legislature to validate certain classes of debenture issues. Owing to carelessness in municipal government many illegal debentures have been sold at one time or another in perfectly good faith. Purchasers of such debentures on being made aware of the irregular character of their holding naturally desire to validate them; to make this possible certain powers of the legislature were delegated to the Ontario Railway and Municipal Board. The municipal act was amended in 1914 to provide for irregularities in water and sewage debenture issues. This amendment reads:

In the case of a by-law for raising money for any of the works or apparatus mentioned in sections 89-94 of the Public Health Act the board may upon presentation of a certificate by the Provincial Board of Health approving the said works, grant a certificate approving the by-law notwithstanding that the certificate of the Provincial Board of Health was not obtained prior to the passing of the by-law or that the by-law does not contain the recital of such approval.

This sub-section was made retro-active since 24th March, 1911.

It is also of interest to note another amendment of the municipal act of last year, which recites:

That where under this or any other act power is conferred on a municipal corporation to borrow money for any purposes without the assent of the electors it shall include not only the power to borrow money to issue all debentures but also the power to agree with any bank or person for temporary advances to meet the expenditures incurred from time to time for such purposes.

The recital of legislation is usually a rather dry affair to those of us who are interested in getting things done. The lack of legislation is a terrific handicap, and it was largely with the idea of presenting you a complete record of the legislation in Ontario that this paper was prepared. As you will see that legislation began in 1873 with the power distributed and vested entirely in the municipal bodies. This has gradually been withdrawn step by step and conferred upon a central body and has been reinforced in such a fashion as to make it effective. Naturally one asks is there any real advan-

tage in such centralization of power. Personally when it comes to a matter of handling town planning and civic developments it seems to be perfectly apparent that centralization is almost imperative. The difficulties that disappear with centralization of power are those of improper administration, limited information and biased opinion.

It was discovered shortly after the passing of the Ontario Public Health Act that its administration required not only a first-hand knowledge of municipal conditions and finances, but also an intimate knowledge of the problems associated with sewage and water purification. To make possible this latter an experimental station for the examination of water and sewage and purification processes was erected in 1909 and has been operated since that date. At this experimental station graduate students in the engineering courses and in medicine are given the opportunity of doing post-graduate work, for which they receive a nominal salary. Their energies are controlled by the Provincial Board of Health and their work is mainly directed to research in the operation of purification units and apparatus. The legislature grants an appropriation each year for this work.

Some few months ago, in order that further advantage might be taken of the control exercised by the Provincial Board of Health and to assist in reporting upon extensions requiring the approval of the board, standard regulation and application forms were designed in the office of the board, one for water and one for sewage. These forms were referred to some seven of our representative city engineers for comments before being approved as a regulation under the act. In arranging these forms the endeavor has been to ask of the designing engineer such information as should rightly be in his possession when designing work of this character. To careless engineers the information required seems to be rather burdensome, but to those who have introduced an orderly habit into their work it causes no inconvenience whatsoever. It is the intention of the board to circulate the information received through municipalities, so that in a general way they may be informed of what their neighbors are doing, as well as the current prices obtained for different classes of material. It appears to the writer that the general result of this supervision will be towards the standardization of all work of this class in the province. Such a consummation is one which we all know to be to the utmost advantage of all concerned. Efforts of this kind must needs be slow in their onward march. Advances

which threaten to centralize power are not as a rule well received by the uninformed.

It has been, and will continue to be the endeavor of the Board of Health of Ontario to make this centralization of power, especially with reference to the control of works pertaining to sewage and water, more in the nature of coöperation than autocracy.

THE CHOICE OF ALLOYS FOR WATER WORK DESIGN

BY HORACE CARPENTER

In the design of water works equipment, the engineer makes use of the various noncorrosive metallic alloys only to such extent as the inaccessibility of the equipment or the danger of interruption of service render it imperative to use some material other than iron or steel. Consequently, the amount of such material has, in the past, been slight in comparison with the magnitude of other materials entering into such work, and the engineer has been content to accept, largely without question, such alloys as were commercially available, without any extensive study of the applicability of any particular alloy to the purpose for which it was to be used.

The increasing magnitude of such work, however, makes the proper selection of alloys of increasing importance to the engineer, and it is the purpose of this paper, not to attempt to set forth in detail any fixed rules to govern selection, but to open the way for discussion and to bring forth the results of the study of others who have been able to make a more detailed study of the matter than has the writer.

Alloys are used for water works construction in two forms:

1. *Castings.* In this form they appear in parts the shape or purpose of which is such that it is possible for the material to pass directly from the foundry to the point of application, with only such intervening fabrication as tends in no way to alter the structure of the material, or to change its physical characteristics.

2. *Bars or tubes.* In this form these alloys must, in nearly all cases, be so fabricated after leaving the foundry that their structure and physical characteristics are materially changed. This fabrication consists of forging, rolling, extruding or drawing.

The ideal alloy must possess three characteristics which, in the order of their relative importance, may be classed as follows:

1. The material must be able to withstand, for an indefinite period, the disintegrating action of the elements with which it is to come in contact, this action taking the form of corrosion, erosion, or electrolysis, either or all of which may be present.

2. The material must be of such structure that it will successfully withstand disintegration due to the failure of its component parts to retain their original relation one to another, and must be free from internal stress which will produce progressive failure entirely independent of any exterior agency. This latter requirement implies a composition capable of successful fabrication under existing commercial conditions.

3. Since the materials are comparatively costly, it is desirable that the physical characteristics be as high as practicable in order that the desired result may be obtained at the least expense.

It is desirable to bring to your attention four of the classes of alloys, and to consider briefly their ability to fulfill the requirements of the above specifications, as follows:

The bronzes, or copper-tin alloys.

The brasses, or copper-zinc alloys.

The copper-nickel alloys, and

The nickel-steel alloys.

The bronzes are of ancient origin and, in slightly varying composition, have been used for many centuries. The most commonly accepted composition today appears to be that of the so-called "naval bronze," consisting of 88 per cent copper, 10 per cent tin, and 2 per cent zinc.

Castings of this alloy fulfill the requirements of the foregoing specifications in a very satisfactory manner. They are noncorrosive in the presence of nearly, if not all, the elements with which they are ordinarily brought in contact, they are easily obtainable, of a homogeneous character under ordinary commercial conditions, are stable and constant in physical characteristics, and the material is one that works well in the ordinary machinery operations.

Their physical characteristics are sufficiently high so that apparatus does not need to be unwieldy or unduly heavy in design to obtain the requisite strength under any ordinary conditions. A tensile strength of 30,000 pounds per square inch, a yield point of 15,000 pounds and an elongation of 15 per cent in two inches can easily be obtained.

Rigid adherence to the composition as given above does not appear essential. The copper may be reduced to 85 per cent, with a corresponding increase in the zinc content, or with a corresponding addition of lead without materially changing the ability of the resulting casting to resist corrosion and without material change in its physi-

cal characteristics. In fact, in the presence of sulphur the addition of lead appears to aid the resistance to corrosion.

Where the material is to be used as a bearing metal, as in the seats of large gates, a considerable variation in the composition is desirable. The United States Reclamation Service has worked out for this purpose two alloys to be used in opposition to one another, as follows:

82.8 per cent copper, 4.8 per cent tin, 4.4 per cent zinc, and 8 per cent lead.

82.7 per cent copper, 7.1 per cent tin, 5.3 per cent zinc, and 4.9 per cent lead.

Experiments by the writer, while indicating the impracticability of attempting to confine the composition as closely as indicated, demonstrate that alloys of this nature containing about 5 per cent lead in one and 8 per cent in the other, with corresponding differences in the tin content, were very satisfactory for the purpose.

Alloys of the above nature may be used for castings only as their high tin content makes it impossible to hammer, forge, roll or draw them successfully, so that, where rods or tubes are required, the content of tin must not exceed 2 per cent, and most manufacturers hold to a maximum of $1\frac{1}{2}$ per cent.

Where conditions of design require greater physical characteristics than shown by the bronzes, or where forged, rolled or drawn forms are required, the engineer commonly resorts to the brasses, of which there are an endless variety, many of them of little value, but of which a number have proven highly satisfactory.

For castings of this character, manganese bronze has been very generally accepted and has given very satisfactory service. A characteristic casting of this material shows a composition of about 56 per cent copper, 40 per cent zinc, 1 per cent tin, 1.27 per cent iron, and 1.8 per cent manganese. It will be noted that the manganese content is small, and it does not appear essential that the analysis of the completed casting show any such content, the manganese being introduced in the form of the ferrous-oxide to act as a flux, and any residue being due to an overdose of the flux, and such residue should not exceed 2 per cent. Such castings, properly made, can be relied upon to show a tensile strength of 65,000 pounds, a yield point of 35,000, and an elongation of 20 per cent in 2 inches. Certain manufacturers use vanadium in the place of manganese, and the resulting castings are of the same general character as

manganese bronze. Castings of this material where purchased in small quantities are generally somewhat more expensive than those made of the bronzes referred to above, and it is the general experience that founders unused to the casting of manganese bronze experience considerable difficulty in obtaining satisfactory results. Where the quantity, however, to be used on a job is sufficient to appeal to founders experienced in handling the material, most excellent castings can be obtained at a price generally from 10 to 12 per cent less than corresponding castings of tin bronze.

Forgings, rods and bars of these alloys show very satisfactory noncorrosive properties and physical characteristics considerably greater than the cast material, the exact amount depending on the size and manner of fabrication, and would appear at first glance to be ideal substitutes for similar steel products. Unfortunately, however, the demand for such rods and bars is of such recent origin that the art of fabrication does not seem to have advanced to a point where the product can be guaranteed against failure by disintegration, or by breaking or cracking without apparent cause. These failures in many instances have not manifested themselves until some months after the material has been fabricated and has passed a most rigid inspection, and have been entirely independent of any load thrown on the material. While no satisfactory solution of the causes of, and no remedy for such failures, have as yet been found, it does appear that the same are caused rather by the methods employed in rolling or drawing than by the composition of the material itself. It would, therefore, appear wise to exercise considerable conservatism in the selection of such rods, until the manufacturers have further perfected themselves, and have solved the various problems of temperature and rolling methods, and to use in their stead some of the brasses which have been manufactured for a sufficient length of time so that the engineer can feel comparative security in their use. Among these there appear Muntz metal, an alloy of 60 per cent copper and 40 per cent zinc, which in the larger sizes of rods can be depended upon to show a tensile strength of at least 40,000 pounds, and Tobin bronze with a tensile strength of 55,000 pounds, which together with other closely allied alloys are readily available.

Comparatively recently, one of our largest manufacturers of rods has produced an alloy containing about $57\frac{1}{2}$ per cent copper, 40 per cent tin, $\frac{1}{2}$ per cent lead, $\frac{1}{2}$ per cent iron, and $1\frac{1}{2}$ per cent nickel,

which possesses high noncorrosive properties, together with physical characteristics equal to or slightly superior to Muntz metal. This material is produced in bars and rods.

Tubes made of an alloy of 86 per cent copper and 14 per cent tin are extensively used in the navy in condensers, where they come in contact with salt water.

The most prominent copper-nickel alloy today appears to be Monel metal, a natural alloy containing about 60 per cent nickel, 36½ per cent copper, and 3½ per cent iron. This material has been very successfully used both in the form of castings and rods for large and small work. Its physical characteristics are at least 65,000 pounds ultimate, 32,000 pounds yield, and 25 per cent elongation for castings, with the ultimate and yield points at least 10 per cent higher for rolled rods. Noncorrosive tests indicate that it is not acted upon by either the acids or alkalies as found in construction work. It has been somewhat extensively used for propellers for battleships, both by this country and by foreign countries. It is also used by many valve manufacturers as a seat metal for valves, for use with high pressure and superheated steam. It is also used in the form of forgings for valve stems for high pressure steam and water valves.

This material has not been in use for a sufficient length of time to determine its noncorrosive qualities under all circumstances, but every indication points to its entire acceptability. It is a comparatively costly material, probably costing in its various forms about 50 per cent more than the corresponding brass or bronze material, but its greater physical characteristics in many cases make this increase more apparent than real. It appears to require considerable skill on the part of the founder to obtain sound castings of Monel metal, and the unsuccessful attempts of some such have prejudiced many against its use.

The value of nickel-steel alloys for members under tension, as valve stems, has not received sufficient recognition by the water works engineer.

While unquestionably not possessing the noncorrosive properties of the brasses or bronzes, a proper steel alloyed with from 20 to 25 per cent of nickel does possess such properties far in excess of ordinary carbon steels and combines with this property physical characteristics such that it should demand the careful consideration of the engineer.

In 1905 the Department of Water Supply, Gas and Electricity of New York City specified for valve stems a nickel steel to contain not more than 0.05 per cent phosphorus or sulphur, between 0.21 per cent and 0.41 per cent carbon, and between 21 per cent and 24 per cent nickel and to have a tensile strength of at least 80,000 pounds, yield point of 40,000 and an elongation of 22 per cent.

One of these stems when examined after five years' service showed no indication of corrosion of that part immersed in water, and only slight pitting of that part exposed to air.

There appears to be very little data available showing the effect of various corrosive substances on alloys. Unquestionably many of the manufacturers of such materials have experimented to a considerable extent on such material, but there appears to have been, in the past at least, a dislike on their part to make public the results which they may have obtained. There are appended to this paper a few results of comparative tests that have come to the attention of the writer and which, while by no means complete or conclusive, may be of some assistance in the selection of noncorrosive alloys.

THE CORROSIVE EFFECT OF MOIST EARTH ON ALLOYS AND STEEL

Six test pieces were imbedded in a box of rich earth, which was kept moist with water and occasional additions of $\frac{1}{2}$ per cent solutions of chlorides of sodium and magnesium. The weighed specimens, consisting of rods 15.2 cm. long by 1.2 cm. diameter, presented about the same area to the corrosive influences in the soil. After having been subjected to the conditions provided for a period of six months, the specimens were taken out, washed, dried and reweighed. The loss in weight represented the amount of corrosion in each case.

SAMPLE	ORIGINAL WEIGHT	LOSS IN WEIGHT	PER CENT LOSS
	<i>grams</i>	<i>grams</i>	
Manganese bronze.....	171.87	0.16	0.09
Tobin bronze.....	162.11	0.19	0.11
Monel metal.....	160.76	0.19	0.12
Manganese bronze.....	161.65	0.19	0.12
Muntz metal.....	163.85	0.55	0.33
Steel.....	139.58	1.45	1.04

All the specimens showed the effect of more or less oxidation on the surface, the Monel metal presenting the least change in appearance as a result of corrosive action.

CORROSION TESTS ON CAST MANGANESE BRONZE AND CAST
MONEL METAL

Relative corrosibility, as indicated by resistance to solvent action of acid solutions and acid solutions containing dissolved salts.

Small specimens of each metal about the same size and weight (35 grams, with length and diameter of 1.2 inch and 0.5 inch) were subjected to the action of 100 cc. of the solutions, in covered glass beakers, for ten days, at room temperature. The specimens were then removed from the solutions, washed, wiped, dried, and re-weighed, the percentage loss in weight indicating the degree or extent of corrosion.

Corrosive or solvent action of 10 per cent solution of sulphuric acid

	<i>Loss per cent</i>
Monel metal.....	0.096
Manganese bronze.....	0.018

Corrosive action of 10 per cent sulphuric acid, containing iron sulphate

Monel metal.....	0.32
Manganese bronze.....	0.37

Corrosive action of 20 per cent solution of hydrochloric acid

Monel metal.....	0.21
Manganese bronze.....	7.34

*Corrosive action of 20 per cent hydrochloric acid solution with common salt
in solution.*

Monel metal.....	0.31
Manganese bronze.....	1.64

Comparative Corrosion List of Various Alloys
Duration of test 6 months

	COPPER	ZINC	LEAD	TIN	IRON	NICKEL
Alloy A.....	57.7	40.1	0.44		0.46	1.3
Alloy B.....	62.6	36.1	0.20	1.1		
Alloy C.....	62.7	35.1	2.20			
Alloy D.....	61.0	38.1	0.20	0.5		
Alloy E.....	89.0			11.0		
Alloy F.....	54.3	27.0	0.10		0.10	18.3

Solution No. 1 Sea water.

Solution No. 2 Ammonium chloride, 20 per cent solution.

Solution No. 3 Ferrous sulphate, 10 per cent solution.

Solution No. 4 Sulphuric acid, 10 per cent commercial.

Solution No. 5 Swamp water,

Solution No. 6 Sodium hydroxide, 10 per cent solution.

ALLOY	SOLUTION NO. 1		SOLUTION NO. 2		SOLUTION NO. 3	
	Loss in weight, grams per sq. in. of surface	Appearance	Loss in weight, grams per sq. in. of surface	Appearance	Loss in weight, grams per sq. in. of surface	Appearance
A.....	0.0184	smooth sound	0.3790	rough sound	0.085	smooth sound
B.....	0.1364	smooth sound	4.2460	pitted, disintegrated	0.091	smooth sound
C.....	0.1590	etched sound	3.5980	very rough disintegrated	0.092	etched sound
D.....	0.1390	etched sound	5.4530	very rough disintegrated	0.093	smooth sound
E.....	0.1700	etched sound	6.8080	very rough	0.089	etched sound
F.....	0.0660	rough length-wise cracks	0.5611	rough deeply pitted	0.041	etched length-wise cracks

ALLOY	SOLUTION NO. 4		SOLUTION NO. 5		SOLUTION NO. 6	
	Loss in weight	Appearance	Loss in weight	Appearance	Loss in weight	Appearance
A.....	0.102	etched sound	0.0030	smooth sound	0.0270	smooth length-wise cracks
B.....	0.110	etched sound	0.0014	smooth sound	0.0300	smooth sound
C.....	0.132	etched sound	0.0043	smooth sound	0.0180	smooth sound
D.....	0.107	smooth sound	0.0117	smooth sound	0.0270	smooth sound
E.....	0.147	etched sound	0.0020	smooth sound	0.0320	corroded sound
F.....	0.063	etched sound			0.0045	clean sound

THE PRACTICAL VALUE OF PUBLICITY TO THE WATER WORKS MAN¹

BY S. C. HADDEN

Occasionally an engineer performs a valuable service by bringing together in one paper data bearing upon a certain phase of engineering science which previously were scattered through engineering literature. It has occurred to the author that he might perform service to the water works fraternity by considering in this paper the value of publicity to water works men and the agencies available for securing it. The thoughts mentioned, therefore, are not brought forward as fresh discoveries, but are submitted in the nature of a review. All of the activities here mentioned have been successfully practiced by some engineers and some engineering societies, but so far as the speaker knows these matters have been very generally neglected by water department officials and by the water works associations.

For the purpose of this paper the water works man is defined as one who gives his entire time to the operation of city water works. Some of the thoughts brought out are not equally applicable to all water systems without regard to ownership, but the limitations imposed by the form of ownership are obvious and need not be indicated in detail.

For the purpose of being specific let us take the case of the superintendent of the municipally owned water works, and consider some of the publicity measures he can adopt to the advantage of himself, of his department, and therefore of his city: (1) The preparation of readable annual reports. (2) The preparation of pamphlets on special subjects for distribution among water takers. (3) The preparation of reading matter for publication in the local papers. (4) Formal advertising. (5) Circularizing selected lists of prospective customers. (6) The making of addresses before gatherings of people in the locality served. (7) The holding of departmental meetings.

¹ Read before first annual meeting Illinois Section, American Water Works Association, March 10, 1915.

(8) The use of hand bills and posters. (9) Identification with and participation in the activities of associations of water works men. These points will be taken up for brief discussion in the order named.

ANNUAL REPORTS

The annual report of the average water department bears evidence of hurried and compulsory preparation. It is perfunctory, lifeless, uninteresting and of small value. Usually it is composed largely of statistical matter presented in the form of tables. Such matters as extensions to the distribution system are recorded almost as minutely and as faithfully as the surveyor records the results of his surveys. Thus the extensions of mains, the installation of hydrants and valves, etc., are tabulated in the published report which, as an exchange, goes into the majority of the municipally owned plants in the country which are of enough importance to get out a report in exchange. Through this agency, therefore, the water superintendent of a town in Utah can learn, if he wants to, the exact location of every hydrant in any large city of Massachusetts having a publicly owned water system. But such information would be so useless he probably would not take the trouble to familiarize himself with it. For reasons clear from the foregoing statements and illustration the average report has little value as an exchange. Moreover, tabulated statistics of the character mentioned possess only small interest to few persons in the home community. These statistics should be filed, but the expense of their publication is unwarranted.

Potentially the annual report is an important publicity agency. Some life should be put into it. The report may well begin with an interesting running account of the important activities of the department for the year. This should be prepared with a view to its publication in local papers. The report should give specific information of general interest to others in the business and to active-minded people in the home community. Some things which fulfill this specification are: Special reports made during the year by outside experts; the making and results of special studies and tests by department employees; summaries of statistics in standard form; descriptions of the handling of problems presenting special difficulties and having somewhat spectacular features, a concise description and history of the water system; numerous photographs

of works finished and under construction; a discussion on the use and abuse of the water system in the home, etc. Such matters would make a report both readable and instructive, and would quicken the citizen's interest in and appreciation of the water works of his city.

PAMPHLETS

A number of water departments have made use of pamphlets to instruct consumers in the proper reading of water meters, and a few have adopted the same means to curtail the waste of water in lawn sprinkling. A notable example of the latter class was the pamphlet issued by the water department of a western city, a few years ago, on the making and care of lawns. The superintendent realized that consumers were using altogether more water than was necessary in lawn sprinkling, and he got out the pamphlet to show people that water alone, even a flood of it, will not make a good lawn. This is a publicity measure which may well be adopted when the water supply is limited, or the pumping facilities inadequate on peak load, and where flat rates are in force. Of course with a fully metered and ample supply, properly determined rates, and adequate pumping facilities there is no occasion for limiting the use of water in sprinkling. The speaker has believed for some time that where it is desirable to limit the use of water for lawn sprinkling, experiments might well be made on grass plats on the pumping station grounds for the purpose of determining the proper amount of water to keep grass green and growing under local conditions of soil, temperature and precipitation. Such experiments would soon furnish a dependable guide to the man who wants to use just enough water to keep his lawn in good shape. The pamphlet furnished the proper means of recording the results of such experiments.

NEWSPAPERS

The newspaper furnishes by far the best publicity medium in a community. Articles should be written in popular style and their acceptance for use is assured. The average local newspaper is hungry for copy and the editor will gladly run readable articles pertaining to the design, construction and operation of the local water system when these matters possess news value. It is a mistake to suppose that newspapers want only highly sensational

matter. They would give more space to engineering matters but for the fact that the staff reporter lacks the technical knowledge requisite to the preparation of articles on engineering works. Someone in the water department should write these articles when anything is to be gained by their publication. When funds are wanted for water works betterments the newspaper columns should be used for the stating of arguments favorable to the improvement or extension of works. This phase of the subject presents such large possibilities that no effort can here be made to cover it except by suggestion. The two thoughts of major importance are that nearly everybody reads the newspapers and that editors are willing to publish any sort of solid information if it possesses news value. The suggested uses of the newspaper also make for friendly relations between the editor and water officials. Surely this is a desirable condition.

FORMAL ADVERTISING

The modern water system is, in a sense, a manufacturing plant of which the product is pure water. The sale of this water produces the revenue. While comparatively few cities have competing water systems, very few public supply systems enjoy a complete monopoly. There are usually numerous competitors in the form of shallow wells. Here is a case where it is to the public good for the large concern to crowd out all the small ones. It is not only the business but the duty of the water official to sell his product to the exclusion of all similar products of inferior grade. All surface wells in cities are polluted or are constantly liable to pollution. They should be closed and an effective method of accomplishing this result is by advertising the good quality of the public supply and the poor quality of shallow well water. In so far as this is a business matter it should be handled by business methods. Advertising copy should be prepared, showing analyses of the competing supplies, and published in the local papers at usual space rates. This has been successfully practiced in several cities. In the *Proceedings of the American Water Works Association for 1910* there is a paper by Mr. Dow R. Gwinn entitled: "Advertising the Water Works Business." This is a most interesting and valuable discussion of this form of publicity. It should be read frequently by managers of both municipally and privately owned plants. As Mr. Gwinn pointed out, water works advertisements are of two types: commercial and educational, but

the latter must, in the nature of things, be a help to the former. Household conveniences such as bathroom facilities, kitchen sinks, and water motor washing machines may be mentioned as items to advertise from the commercial side. Under the educational side good will, among other things, can be built up.

CIRCULARIZING LISTS

In any locality it is not a difficult matter to obtain a list of the names of the householders who are within easy reach of the distribution system of the public water supply but who are using shallow well water. This list, in part or in its entirety, can be circularized to advantage. Circulars should be drawn up to show the superiority of the public over the individual supply, giving data on cost of service, relative purity of the two supplies, the convenience of having, at all times, water under pressure in the house, etc. These circulars may be either mailed or delivered by an employee of the department. This publicity measure possesses the considerable advantage of reaching surely and directly the persons who constitute the department's best "prospects" for new business.

ADDRESSES

There are times when publicity through addresses before gatherings of the people will be helpful to the water official. Again let us suppose that an election is to be held so that the people can vote on a bond issue for water works improvements. At such a time if there are any speech makers in the water department they should seek an opportunity to address such bodies as chambers of commerce, civic associations, and clubs of all sorts. Even the high school classes may be addressed to advantage, for in these times many of the high school age have already enjoyed much greater educational advantages than did their parents and their influence at home is, therefore, out of proportion to their age and general experience. At times of rate revision addresses are also helpful. This form of direct appeal is, of course, a very effective publicity measure. In ordinary times an occasional descriptive lecture on the history and construction of the local water system before an actively interested body is always worth while.

DEPARTMENTAL MEETINGS

The progressively managed municipal water department of San Diego, California, has recently secured considerable publicity at home and throughout the country by holding what might be termed a school for water works employees. The department does all its construction work by force account. Considerable work of this character is now going on and several hundred men are employed. The superintendent has caused to be held monthly meetings at which all the employees get together for the purpose of getting better acquainted and in order to familiarize each of the bureaus, into which the department is divided, with the work done and the methods employed in the other bureaus. Thus a study is made of the procedure within the department from the time a request for material is issued until the material is delivered on the ground and ultimately placed in the improvement for which it was ordered. At these meetings the various construction foremen and other employees of corresponding rank in other bureaus read papers in which they record their experiences and the methods they employ in handling the work in their charge. The men take a keen interest in the meetings and the results obtained have considerably raised the efficiency of the department. Good fellowship is also promoted, as it brings the men and foremen together, oftentimes eliminating imaginary grudges. The superintendent gets in direct personal touch with the various employees by means of these meetings. The papers read are good; those the speaker has seen are in quality fully up to the average paper before the smaller water works associations. Of course each meeting is reported in the local papers and good publicity is thereby secured. Effort toward self-improvement is universally commended in individuals and the same must be true of water departments.

HAND-BILLS AND POSTERS

Hand-bills have been used in emergencies to supplement newspaper announcements advising consumers to boil the water. They have also been used in house-to-house canvasses for the purpose of curtailing the waste of water from defective plumbing and careless use. Posters have been used for emergency purposes as stated for hand-bills. They have also been used for advertising purposes. Thus in one city where the water works had to compete with shal-

low, private wells, crayon sketches on large posters were drawn to show how the water in such wells becomes polluted from various causes. These posters were conspicuously displayed on bill boards in various parts of the city. In general, hand-bills and posters should be used only for the purpose of supplementing other publicity measures.

IDENTIFICATION WITH WATER ASSOCIATIONS

Some publicity usually comes through local papers to the water department which sends a delegate to the convention of a water works association. This is the best evidence the community could have that its water department management is endeavoring to keep up with the times. So much for the department. As for the delegate as an individual there can be little doubt that if he attends the conventions regularly and takes an active interest in the proceedings he is safeguarding his future in the business. The thoughts he takes to the convention strengthen him with others in the business; the thoughts gained at the convention and taken back home tend to fortify him in his position in his community.

PUBLICITY WORK BY WATER WORKS ASSOCIATIONS

Delegates to water works conventions, as is the case in all other engineering society meetings, are rather prone to say that the public should do thus and so. The trouble with this practice is readily illustrated. Suppose the subject under discussion is the neglect or incompetent operation of small filtration plants. The average delegate knows these plants are often, perhaps usually, handled to poor advantage. The fault is said to lie with the public and this is true, but the fact should be stated directly to the public; that would be education. When a water works man tells one or a group of his contemporaries that small filter plants are often abused, he states a thing they all know and deplore. That is commiseration, not education. It seems to the speaker that there has been too much of this. There can be no doubt that the associations have always been willing and anxious to educate the public and they have accomplished much by indirect methods. Much more could and should be accomplished by direct methods. The author believes the American Water Works Association should have a publicity committee whose function it would be to prepare matter pertaining

to the water works business for publication in newspapers. Such a committee would increase immeasurably the usefulness of the association. Thus let us suppose the association feels that small filters are too often neglected. Then the publicity committee should prepare short articles on that subject and send them to newspaper editors in towns having such filters. That seems the best way to bridge the gulf which now lies between those competent to teach and those who need instruction.

Again the public needs to learn the importance of having trained men in charge of water works operation. College training is not implied in that statement, for the man who has had years of practice, supplemented by the proper amount of reading and study, is a trained man in the sense here intended. This is a matter the suggested publicity committee might well work upon. It is not so essential that municipal plants be taken out of politics as that trained men be appointed to take charge of them, and educational work along this line is certain to be productive of much good to the water works business. Even politicians can be made to see that the appointment of trained men is a vote catching medium.

As stated earlier in this paper, in discussing newspaper publicity, editors will gladly accept for publication such matter as the suggested publicity committee would prepare. In the process of handling this matter the editor would become well informed and could be depended upon, in the majority of cases, to bring the same subjects up again in his editorial writing.

All the water works associations are seeking new members. In this connection it is interesting to note that the membership of the Cleveland Engineering Society increased over 50 per cent within two years after the appointment by the society of a publicity committee. This is a remarkable rate of growth for a society over 30 years old. Publicity work, such as suggested for the American Water Works Association, will surely add many new members each year.

DISCUSSION

MR. DOW R. GWINN: The speaker listened to Mr. Hadden's paper with much interest, as he is a thorough believer of publicity in the water works business. The average customer has very little idea of the difficulties which the water works men must meet in supplying water. If our customers knew something of the problems that we are compelled to solve, they would be more charitable with

their criticism and would pay their bills with better grace. It is good policy to take the public into your confidence and let them know what you are doing.

Mr. Hadden very kindly referred to the paper which the speaker presented to the American Water Works Association at the New Orleans convention in 1910 and, by the way, he has a number of extra copies of this paper which he would be pleased to furnish to anyone who is interested.

Mr. Hadden has well said that the best publicity medium in a community is the newspaper. While the speaker would not confine publicity work to newspapers, he believes that the major part of the money spent along this line should be used for newspaper advertising. We have contracts with our daily papers for a 1 inch advertisement for every day in the year, so that the company is always represented in every issue of each of the daily papers published in the city. We have about forty different ads which are used for this purpose alternating from day to day and when the entire lot is used, they commence over again. Some of the ads read as follows:

Give up the back-breaking pump,
Use Filtered Water.

City Water in Terre Haute
is purified by scientific
methods in charge of an expert.
It is tested every day.

Filtered Water Kitchen Sink—
6 Room House—1½c per day.

Don't be tied to the Pump.
Get City Water in the Kitchen.

Good Morning: Have you
used Filtered Water
This Morning?

Pure Filtered Water
Bath Room in 6 room house
3¢ per day.

The Good Landlord puts
City Water in Kitchen and
keeps his tenants

The Public Be Pleased.
We strive to make City Water
Service as near perfection
as possible.

Sometimes we use a half page; sometimes we use a whole page, and on one occasion, we used a double page, when we used a large cut showing how well water is contaminated from privy vaults. We pay special attention to the headlines, some of which are as follows:

The Public Be Pleased.
Come on in, the Water's fine.
Don't be tied to the Pump.
Get on the Water Wagon.
Fix up the Old House.

We have used quite a number of cuts and on several occasions, used a large cut running across the page, showing the park at the pumping station and a portion of the buildings, with the headline,

THE HOME OF PURE FILTERED WATER

We have used some posters, but as stated, believe that the best results can be obtained by advertising in the newspapers.

About four years ago, we did considerable circularizing. First, we went through the street index in the local directory and checked off the addresses of all who were using city water and found that there were over 4000 premises along the line of our mains that were not using water from us. We then prepared a half dozen circular letters, which were printed on the mimeograph and the addresses put on with the typewriter. The typewriter ribbon corresponded very closely in shade and color to the ink used by the mimeograph and the letters had the appearance of being typewritten. These letters were mailed to more than 4000 people and were accompanied with a circular on colored paper, with attractive type and, in some cases, with cuts. The letters were sent out about a week or ten days apart. One man came in and said that he had received three of our letters and was ready to put in city water. He was the head of a large institution which uses \$250 to \$300 worth of water a year.

One of the best things that we sent out in connection with these circular letters was a pamphlet entitled "An Important Trial," which purported to be the trial of Mr. City Well and Mr. Privy Vault. It was gotten up in legal style and attracted a good deal of attention. To those who are interested, the speaker will be pleased to send a copy of this pamphlet.

In addition to the publicity work already mentioned, will say that we believe that a good way of getting the public familiar with what we are doing is to have them visit our pumping station. Working along this line, we engaged a landscape gardener, spent hundreds of dollars for trees and shrubberies, fixed up a tennis court for the use of the public, and really have a very beautiful park at our pumping station. We invite the public to use our tennis court and to have picnic lunches at the plant. On several occasions, we have invited the local medical society to visit the plant and have served supper. We have also had the Young Business Men's Club, the Manufacturers' Club, and also the city officials. Some of the

teachers in the public schools have taken their classes to the plant and Professor Bruce, who has charge of the chemistry class at the State Normal School, makes a point of taking each of his classes to the pumping station and gives them a talk on the Purification of Water.

Accepting an invitation from the Manufacturers' Club, the speaker gave them a talk on the Methods of Testing Meters, the Purification of Water and Results Obtained. He had a number of charts, showing the daily average bacteria in the river water and in the filtered water, and also the reduction in cost of water to residence consumers who were on meters.

There is another method of publicity which we use that brings good results: Our bills are payable quarterly and at the beginning of each quarter, for a period of ten days, we have a notice in the paper to the effect that "Water bills are now due and payable. Pencils to first comers." We buy 50 gross of lead pencils at one time at \$3 per gross, or a trifle over 2 cents apiece. They are first class lead pencils, coated with white enamel, with gilt top and rubber and inscribed in gilt letters, "Compliments Terre Haute Water Works Co." "Pure Filtered Water—Low Rates." These pencils are distinctive and when one takes out a white pencil, practically everyone present knows that it is one of the water works pencils, and an expression frequently heard is "I see you have paid your water bill." The beautiful white enamel is suggestive of the purity of the water, while the gilt letters suggest that the water is good as gold.

As these pencils are given out from the first to the eleventh, at the time the quarterly payments are due, the people have learned that it is better to pay their bills promptly and get a pencil. When bills are not paid promptly, we must send a notice by mail with a two cent stamp and envelope, making the cost equal to the cost of a lead pencil. Hence, we believe that outside of the value as an advertising medium, we are getting a good return on the investment.

In our city, where water can be secured from the ground at a nominal expense, it is necessary to educate the people: to show the advantages of using water under pressure, and also the danger of contamination of water taken from the ground on account of the large number of privy vaults. One day a man came into the office and wanted water for sprinkling purposes. We suggested that he also should take the water for domestic use, but he quickly replied

that he had a good well, the best one in that part of the city, that people came from several blocks around there to get water from his well. We asked him if he had ever had the water analyzed and he said no, that the water was all right; it was clear and nice and cold and it was not necessary to have it analyzed. We offered to furnish him with a barrel of salt, free of cost to him, if he would put it in the privy vault and then if the water from the well became salty, he would know where some of it was coming from. He refused to accept the proposition and when we pressed him for a reason, he said it might spoil his well.

The average water works man will want to know if advertising the water works business pays and in reply, the speaker will say that when he came to Terre Haute 14 years ago, the company had about 2000 customers, after being in the business for 27 years. We now have about 7000 customers and the gross earnings are more than double what they were 14 years ago. Of course, all of this increase is not due to advertising, for we have made a point of serving a very high grade of filtered water. We have an unusually good plant and are getting fine results in the way of bacterial reductions. We have a laboratory and make daily examinations of the filtered and unfiltered water. Good water and good service attract business, but advertising is a material help in developing business.

ANCIENT AND MODERN ACCOUNTING FOR PUBLIC UTILITIES¹

BY EDWARD A. PRATT

The title "Ancient and Modern Accounting for Public Utilities" might presuppose starting with by-gone ages, but those words were selected because "ancient" books, forms and accounting records have but recently been prescribed and insisted upon by a public utility commission in one of the states of progressive and up-to-date United States of America.

With the hope that the utilities of Illinois may see what burdens may be placed upon them by those holding political positions, the thought of appearing before you came, and time in preparing this address has been taken from a very busy life. What must be done in Illinois is for the public utilities to demand and secure forever their personal liberty of keeping their individual accounts on the best books and forms they can find or design, provided that each and every item of receipts and expenditures shall be recorded according to a uniform classification and distribution. The annual reports of all utilities proper to be compared one with another, must be similar and uniform to the minutest detail, and all made according to every requirement of the Public Service Commission of the state. Uniformity of classification and annual reports must be insisted upon by the state of Illinois and complied with completely by every public utility in this state.

"Ancient" account keeping was "single entry"—a record on a stone, piece of bark, wood, etc. Occasionally now we hear single entry urged, when one playfully tells another to "Put it on ice" when no intention of payment is indicated. Answering an oft repeated question, "single entry" means the recording of a charge or a credit in one place without a counter balancing credit or debit. This system permits of unlocated errors and provides no balancing of accounts to prove accuracy.

When double entry was originated, a two column book called a

¹Read before first annual meeting, Illinois Section, American Water Works Association, March 10, 1915.

journal was used, so that the left column might contain the debits and the right column the credits. The double entry ledger was also designed back in those ancient days. Both of these forms have almost entirely disappeared from modern account keeping, but another state has prescribed and insists on the use today and in future of these forms, which are almost identical with the books our great grandfathers purchased at the corner grocery.

Here are drafts of these ancient forms prescribed for the use of modern utilities which use tungsten lamps, telephones and typewriters. Why should not this State Utility Commission, with equal right, prescribe tallow candles, and that all messages be written in longhand and sent by messenger. Does not this illustrate the danger in delay in making yourself heard before forms are prescribed rather than be forced to use unsuitable forms or fight for the right afterwards to use your own modern accounting forms and specially designed records?

Right here let it be known that the State Public Utilities Commission of Illinois has repeatedly expressed their policy as not to even recommend forms and systems. They will provide forms for annual reports and carefully written instructions covering the classifications of accounts and analysis of receipts and expenditures. Let us hope they will always adhere to that policy, which they will do if urged to do so by the utilities of this state. Personal liberty must be expected and demanded.

The Interstate Commerce Commission has provided very complete instructions for many utilities, but does not require the use of any particular forms for keeping the accounts. The following quotation is made from a uniform system of accounts for telephone companies:

The bookkeeping system here described is suggested for the use of small telephone companies—the use of this bookkeeping system in whole or in part is not obligatory and companies may adopt for the present any bookkeeping system desired for them, if the one chosen will produce the results required by the system of accounts.

Before considering the forms and systems of bookkeeping, let us examine a book of instructions. In this printed instruction book for water utilities issued by a neighboring state, we find many things incomplete, contradictory, and impossible. In the opening lines of instructions, we read:

Operating revenues, earnings from commercial sales. Credit this account with all revenue from water sales to commercial consumers, both where the revenue is dependent on the quantity of water taken as recorded by meter, and where such water is sold at flat rates independent of the quantity taken.

In no place within the covers of this book is the word "revenue" defined. One is left to make his own interpretation of the word "revenue" and to keep his books accordingly. One man may have been keeping his books on a basis of cash received and cash paid. In such a case the "revenue" is made up of the cash received day by day and month by month through the year. Where the flat rate alone prevails, the collections are in advance of service, the cost of providing which is yet to be paid. Where both flat and meter rates are used, part of the cash is for service in advance, and part for the water that has been pumped during previous months. "Revenue" in either case does not coördinate with operating expenses.

The manager of another plant may report as "revenue" such an amount monthly and yearly as closely represents the amount paid or to be paid for water service had and delivered on an entirely different but more accurate basis. He may take one-third or one-sixth of monthly "revenue" from flat rates paid in advance. He may credit "revenue" monthly with hydrant and similar rentals. He may credit as "revenue" monthly a carefully calculated sum for the accrued meter rates, which are payable at a later date, either monthly, quarterly or semi-annually.

Can any proper comparison of revenue and expenses, assets or liabilities be made when the most important element in determining rates and values, namely "revenue," is so incompletely described as to justify such a wide difference in its determination in the preparation of the annual report to the commission?

In this same book, we read the following instructions as to taxes: "This account shall cover all taxes chargeable against the water utilities." Does anyone know whether they should report as taxes for the year 1915 the amount that was assessed as at last April but payable in the year 1915 for the year 1914, as being the taxes for the twelve months to December 31, 1915, or the twelve months to April 1, 1915, using in the report for the year 1915, four months of the 1915 levy and eight months of the 1914 levy? Should a utility report as taxes the amount paid in cash in 1915 as required by the government in the Income Tax Report, or should they report as

taxes for the year 1915, the taxes which are assessed in April, 1915, for that year? Who can state positively what is meant in this printed book of instructions, as the charge against revenue for taxes in making an annual report, and can he be sure that his report can be correctly compared with that of every other water utility in that state?

Pick out one more word—"depreciation," with the instructions appearing in two places. On one page we read:

Every public utility shall carry a proper and adequate depreciation reserve to cover the full replacement of *all tangible capital* in service—when any building, structure, machine, facility or unit of equipment which, at the time of its construction or installation, was classified as tangible capital, becomes through wear and tear economically irreparable, the substitute therefor, having substantially no greater capacity than the unit for which it was substituted, shall be charged to the depreciation reserve account. When, however, a building, structure, machine, facility or unit substituted has a substantially greater capacity than that for which it was substituted, the cost of the substitution of one of the same capacity as the unit replaced shall be charged to depreciation reserve account, and the remaining cost of actual substitution shall be charged to the appropriable construction and equipment account.

A careful application to the accounting records of these instructions would lead one to charge the entire cost of a new tubular boiler of exactly the same heating capacity as a worn out flue boiler to reserve depreciation account. If the tubular boiler is 25 per cent greater in heating capacity than the old boiler, then 75 per cent of the cost of the new tubular boiler must be charged to depreciation reserve account and 25 per cent to new equipment in the power plant. This would cause the inventory of the plant to show an old flue boiler which had been scrapped and one-fourth the cost of a new tubular boiler, which is then intact and in use. It appears that, in an effort to follow these definite instructions, one would soon have a very tangled plant inventory which it would be impossible for anyone to check up.

In passing, it should be noted that the definite instructions in the first sentence quoted above would indicate that the commission requires every public utility to carry a proper and adequate depreciation reserve to cover the full replacement of all tangible capital in service. Does this mean that they shall set aside a reserve large enough to absorb the value of the entire investment in tangible

capital? If so, when the plant has been all paid for by such charges to revenue account, to whom would the plant then belong? Clearly the definite instructions are not to be followed.

While stating that the proper and adequate depreciation reserve shall be set up by charges "monthly," nothing at all definite is stated as to how one should arrive at the rate per cent of depreciation. To follow this, shall one take an average per cent on the whole plant investment, or must one select different rates for few or many different classes of buildings, machinery, fixtures and equipment? If so, what rate shall one use?

Depreciation is too uncertain a quantity to be explained in a few words so that it may be applied properly by plants of even similar equipment and capacity. A very large factor in determining proper depreciation is the policy of each individual utility in the conduct of the plant, some being careful to keep the plant in first-class condition and others allowing them to deteriorate, in which latter case a much larger annual rate for depreciation must be used.

However, enough of these. They show that uniformity of definitions and practices would keep a number of men busy for a number of years without troubling them with forms and books on which others attempt to follow their instructions. We can now consider the tools of bookkeeping, the books, forms and systems of accounting, ancient and modern.

The single entry bookkeeping records on stone made by the ancient Babylonians and Egyptians remain to this day without record of payment. Later on, wood, paper and other materials were used for keeping accounts and it is a thing to be wondered about how the ancients, especially the very rich ones, were able to keep their accounts when, in these modern days, frequently there is so much difficulty experienced in making books attest the historical facts of a business enterprise.

Among the books prescribed and insisted upon is an ancient ledger very similar to one which might have been purchased at a general store fifty or seventy-five years ago. It is surprising to find this old-style ledger included in the recommendations of the Interstate Commerce Commission, but not prescribed by them. This old ledger is a so-called double entry book, the debits being written down one side of the page and the credits the other side. The result is that 40 per cent of each page is blank paper, for the reason that almost all accounts are one-sided, containing a larger

number of either debits or credits. It is also very difficult to take off trial balances or to check out old trial balances from such a ledger, and there is not room enough in the explanation column to state clearly the reason for the entry, which should be done in every private ledger account.

We have here a modern tab-cut looseleaf, self-indexing private ledger. In the front of this ledger is a cash journal for entry of transactions of a private nature which should not be shown upon the general books of a corporation. They can in this way be kept entirely in the private ledger. Following this, are the regular ledger accounts, which are grouped into assets, liabilities, income, expense and personal accounts. The accounts in this ledger are arranged so that all the assets will follow in proper sequence as will also the liabilities, the income accounts and the expense accounts. This grouping of the accounts makes the trial balance as drawn directly from the ledger a financial statement and an income profit and loss account, if the proper entries are made monthly in all of the ledger accounts.

You will observe also that the ledger page has one date column, one long explanation column, one folio column and finally, three columns for "debits, credits and balance." With this ledger no blank space appears even when the pages are filled, for each line is used. The balance, whether a debit, or credit, can be shown at the end of each month and after each entry if so desired. With this kind of a ledger, one could draw off a balance quickly at the end of any month, even years afterwards and the drawing off of the monthly balance and checking of the current records is very much easier than the ancient ledger described above.

Attention is also called to the tab-cut self-indexing feature of the modern ledgers. With the ancient ledgers, one must first hunt the ledger page of an account by looking in an index, and then leafing through the old style book until the ledger page is found. With the modern ledgers, should one desire an asset account, it is only necessary to lift the asset tabs, place the thumb on the account wanted, because the name shows on the tab at the right hand side, and, with one turn of the hand—open the ledger at the account wanted. This tab-cut feature is of great convenience in a private ledger, even though the postings be comparatively few, but, in a consumer's ledger, the use of the tab-cut ledger leaves reduces the time of posting fully 60 per cent and is therefore of a great economical value.

Next, look at the journal which has been prescribed. It is surely an ancient form and quite unnecessary in modern bookkeeping. Here also are two ancient cash books prescribed, one a general cash book and the other a daily cash receipts book. Here also is another unnecessary book which is called the bank book balance.

The four ancient books referred to can easily be supplanted by two modern books, one an income cash record and the other a bank check register in large utilities, while smaller utilities can use one book, a cash journal, to take the place of the four books referred to above. This, of course, means centralizing the bookkeeping records into one or two forms, reducing the clerical labor, and minimizing the possibility of making errors in one or more of the four books. The arrangement of columns of these modern books makes it entirely unnecessary to use the so-called journal, which has almost entirely disappeared from modern bookkeeping.

Attention is next called to an ancient voucher record, truly so-called because designed with the idea that there shall be a column for every desired classification of expense. Here is the voucher record which has been prescribed. The size of the larger leaves is $17\frac{1}{2}$ by 28 inches and the size of the shorter or inserted leaves is $17\frac{1}{2}$ by $26\frac{1}{2}$ inches. There are over 200 columns in this book. If the leaves were stretched out one after the other, it would extend over eight feet. When opened upon the desk, the pages extend twice twenty-eight or, leaving room for the binding edge, about four feet wide by a foot and a half up and down. Column number 1, superintendent, would probably have but one entry a month and, yet in making an entry in that column, all of the rest of the lines over all of the pages would be blank and, of course, waste paper.

Every distribution of expenditures required in this ancient voucher record has been provided for in this modern voucher record-expense journal which, when open on the desk for use, only measures 28 inches by $11\frac{1}{2}$ inches up and down. This small voucher record has been in use in several utilities and in many mercantile institutions for years and permits of almost unlimited analysis of expenses. This modern voucher record is not limited by the number of columns or the length of the pages, because modern accounting methods provide a chart distribution of expenses. In this way, the chart or account number is entered opposite each item as recorded in the proper column in the voucher record. Further elaboration of the expenses under any classification can be made by simply adding another sub-account number and labeling the charges as made.

With the ancient voucher record, the accounts follow each other across the page. If one wants to know the cost of operation of the steam power pumping plant, one must add the several columns one to another, so also if one wishes the cost of maintenance of the power plant or operation or maintenance of the pumping department or engine room or any other summary of the expenses, a summing up of these accounts must be made from this very large voucher record.

In the modern voucher record expense journal, the footing of each of the columns gives the total expenses into the general classifications provided by the utility commission. The summaries of the sub-classifications are very quickly made at the end of each month, which amounts are carried into the monthly report or trial balance books. The cost of the necessary sheets for a utility of the ancient voucher record would be at least six times as much as the cost of sufficient sheets of the modern voucher record.

Furthermore, and of far greater importance, is the fact that this modern voucher record is also an expense journal. Instructions for its use require that all invoices or payments due for expenses or from material and supplies must be entered in the record each month before closing. After the entry of accounts payable records or vouchers for moneys due to creditors and, including the monthly pay roll, necessary journal entries are made as shown in the voucher record. Here you will find the journal entries such as the following: A debit to steam operation account and a credit to fuel stock account for the number and value of tons of coal consumed during the month. Another entry charges capital investment and credits stock accounts with the value of meters and materials used in setting the same, crediting properly to stock accounts. Likewise entries are made for services installed, for meters repaired and services repaired, for insurance expired or bond interest accrued, for the reserve depreciation when one can find out on what basis to calculate it.

The use of the modern voucher record as an expense journal, makes it possible to get into one book every item of expense properly classified in the month when the expense was incurred, regardless of when paid. It requires only one posting of monthly totals to the general ledger account, and eliminates postings in expense accounts from cash books and the old-style journal prescribed, but now considered obsolete.

Time might profitably be spent in considering the old-style voucher check, which is twice the size of a bank check, when a modern

voucher check can be made to show with sufficient detail the items for which the payment is made and yet be no larger than the usual bank check or draft. We might also consider the very intricate method prescribed for keeping pay rolls and distributing wages to proper expense accounts. There are several forms of different sizes, while modern accounting requires only one pay roll and one weekly or semi-monthly time sheet or card for each employee. The latter are very simple, yet complete forms, which permit of minute analysis and strict adherence to the classifications described by any utilities commission.

And finally let us consider the consumers' ledger, both the old and new forms, for the major portion of the bookkeeping of a water utility consists of correctly recording the charges and collections for water sold to thousands of consumers. This means, in some cases, thousands of individual ledger sheets, or hundreds of pages on which several ledger accounts may be carried.

We have here a very complete ledger form prescribed, but it is an ancient form, because it is not modern. It lacks the tab-cut self-indexing feature, which alone saves fully 60 per cent of the time in making postings and in finding ledger accounts.

This modern tab-cut self-indexing looseleaf ledger is designed to carry in one book all the flat and meter consumers within the limits of the ledger capacity. If the services are carried in numerical order, then the ledgers will be carried in the same order and the consecutive service number will be put upon the tab at the left side so that one may turn almost instantly to any service number, first finding the larger index sheet and then anyone of twenty-seven accounts under each tab. It is recommended that white sheets be used for flat service and buff sheets for meter service, and that these be all filed together. Under this method, every service in every block of the city could be located in the ledger quickly. One could turn to Adams Street, and, following consecutively, find every service tap in the 1300 block South Adams Street. One would see that the first two were meter consumers, the next one was a flat consumer, the next three meter consumers, the next service tap was out of commission, and the next two flat consumers, etc.

If one desires to carry the accounts in any special grouping, it is possible to do so with the modern self-indexing tab-cut ledger and to find any one of the accounts in at least one-fourth of the time that one could find it in the old style Boston ledger or the old-style-loose-

leaf ledger. Since most of the work is done in recording charges and collections, the use of this modern ledger will make a great saving in time of clerks, managers and superintendents where it is installed.

As has been stated previously, the State Public Utilities Commission of Illinois have so far adopted the policy of non-interference with the forms and systems of bookkeeping in use, so long as the annual report can be made out correctly and completely. The utilities in this state will be permitted to make use of any ancient or modern bookkeeping methods, but it is quite probable that, should the commission find out that the expense of account keeping in any utility is much larger than it should be, they would then insist on modernizing such accounting, for the reason that the unnecessary expense will be a charge against income to be paid out of money received from water consumers. Such has been clearly the position assumed in other states. It, therefore, follows that, if the utilities of Illinois shall in future be allowed individual liberty as to account keeping, they must at least make use of the best modern accounting forms and records which they can secure or design and, thus, avoid criticism in their home cities and by accountants for the Public Service Commission. The utilities of this state are to be congratulated that they have such latitude, for, in another state, they are prohibited from keeping accounts on any forms other than those prescribed by the commission or approved by them and this commission have so far assumed the position that the law made it incumbent upon them to provide a uniform set of accounting records and compelled the utilities of the state to use only their forms, thus entirely destroying individual liberty in the use of bookkeeping forms and records.

And, finally, you may justly consider what has been accomplished by those public and private accountants and auditors who have been striving, and will in the years to come, strive to provide the owners and managers of public utilities complete and concise, yet thoroughly trustworthy records of all the operations and financial transactions of each enterprise. It is hoped that professional accountants, as well as the professional engineers, may be recognized for the services they have been rendering in making, not two grains of wheat to grow where one grew before, not two gallons of pure water delivered at the cost of one impure gallon, but who have been providing records of accounts so that one group of figures takes the place of many, and so that one book of moderate uniform size takes

the place of several books of irregular sizes, and so that two books may contain all the important records of a very large utility for two or several years. The saving of time and money in account keeping is of deep interest, but far greater is the value of a set of accounting records so complete that any necessary fact can be found quickly or any needed comparison of one period with another, or one utility with another, be made without delay and in the full confidence that nothing has been omitted from the accounts of either period or utility. Then only can the engineers and managers draw the conclusions based on all the facts.

ILLINOIS UTILITIES COMMISSION AND THE WATER WORKS COMPANIES¹

By C. G. BENNETT²

State regulation of public utilities in Illinois commenced as early as 1871 when the Railroad and Warehouse Act went into effect, providing for a commission to regulate these two quasi public businesses. From then on down to a year or two ago, various acts were passed affecting other utilities, such as gas, telephone and telegraph companies, but there seems to have been no attempt on the part of the state to regulate water utilities. This was apparently considered a matter coming under the jurisdiction of the municipality for the reason that the field of operation of a water company is local and confined to the limits of the municipality.

To compile all these special acts into one compact form and further to give the state supervision of all phases of the organization, operation and character of service of every utility, an act was passed in 1913 known as an act to regulate public utilities. This is a most carefully drawn statute and gives the commission it creates a firm foundation upon which to stand when exercising the various powers delegated to it by this law.

The Public Utilities Law provides, among other things, that the commission may establish a uniform system of accounts, must pass on all contemplated stock and bond issues before the securities can be placed on the market; that all mergers, consolidations and reorganizations must be approved by the commission before they become effective, and last, and probably most important, the commission is given the power to determine and make reasonable rates and to establish standards of service. These are but a few of the more important subjects with which the law treats but are sufficient to show the scope of the work that the commission has to do. The utilities under its control are those engaged in the transmission, production, sale or delivery of heat, cold, light, power, gas, oil,

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² Read at first annual meeting Illinois Section, American Water Works Association, March 10, 1915.

electricity or water and the transportation of persons or property and transmission of telegraph and telephone messages between points within the state. By the definition of a public utility as contained in Article 10 of the law, plants that are municipally owned or operated do not come under the supervision of the commission and, therefore, municipal water plants have no dealings with the commission. There is, however, at the present time, a bill before the legislature to amend the law and bring all municipally owned or operated utilities under its jurisdiction.

The first meeting of the five commissioners, comprising the administration department of the commission, was held on January 2, 1914, one day after the law went into effect, and the cases pending and docket of the Railroad and Warehouse Commission were taken over. As this is a little over a year ago, the commission is obviously quite young; in fact, one of the youngest of the many similar commissions that are in operation in other states. In spite of the youth of the commission and of the great amount of work brought before it almost from the time of its inception, it has been able to meet the demand placed upon it. The organization of the commission is made up of four departments, namely, the administration, legal, engineering and accounting. Each of these departments has had to carry on the current matters together with the vast amount of detail incident to compiling of schedules, forms and regulations that will be used in the future to expedite the work. This explanation is here given to show the reason why so much of the work the commission is now doing is in the process of development and not available for the utilities. In other words the commission is just a little beyond the formative stage in many of the routine matters, although in utility regulation, it is old in experience.

Before utility commissions came into existence many noted cases of dispute between utilities and their consumers were fought out in the courts, several being water cases. The decisions of these cases have laid down the principles that guide the commissions in their decisions. Now that commissions are handling these cases it does not mean that the courts have no jurisdiction, for any case decided by the commission in this state can be appealed to the Circuit Court. This means that the courts regulate the public utility regulators. One function of the commission is to settle these disputes in the most expedient and inexpensive manner possible.

All complaints that come to the commission are settled in one of two ways, the method being determined by the nature of the case.

Where one or a few consumers only are affected by the decision to be rendered, as the dispute over a water bill or the adequacy of a certain street main, it is put down as an informal case. When the character of the service given or reasonableness of the rate is questioned, the decision, of course, will affect the entire community served. Such cases are put down as formal. This division is made so that the decision can be reached in the shortest possible time and to put all cases through the same channel would not be practical.

Informal complaints are settled by the commission in a way that the name indicates—informally. The consumer's complaint is received, given a number, referred to one of the three departments, legal, accounting or engineering, and immediately acknowledged. It is often evident that the complainant has a mistaken idea as to his rights and in such cases his complaint is disposed of by pointing out wherein he is wrong. More often a copy of the complaint or the substance of it is sent to the water company and a request made that a full statement of the facts be given. The complaint often settles itself at this juncture because the utility and the consumer get together and arrange it to the satisfaction of both. When this is not done and when all the facts have been put before it, the commission renders a decision in a letter to both parties, which decision must be accepted or the matter again brought up and this time as a formal case. Perhaps sixty per cent of the cases coming to the commission are informal ones, but it is remarkable how few of them involve water utilities. Many companies have been taking the letters of the commission on these informal complaints to their attorneys for reply. This procedure the commission has not contemplated and is considered practically a useless expense. All that is desired is a clear statement of the facts surrounding the case, and any officer of the company acquainted with these facts can give the information just as satisfactorily from the staff's point of view as can the attorney. The commission's letters are not written by lawyers and it would not seem that they should necessarily be replied to by lawyers. In other words, this practice is injecting an unnecessary expense into the settling of an informal case, unnecessary from the commission's point of view.

The other, or formal cases usually cover the question of rates or service affecting the community served as a whole. By far the majority are brought by the community because the idea is prevalent that the rate charged is too high, and the parties to the case

are the city and the company. A date is set for a hearing at which both are represented, usually by counsel, and all testimony is recorded. At this first hearing both sides are given a chance to give their views on the matter. Sometimes it happens that the key to the situation has been overlooked, and, upon its being pointed out by the presiding commissioner, and a suggestion made that they adjourn for a time and talk it over, an agreement results that is satisfactory to both parties. A number of water rate cases that threatened to be protracted and expensive were settled in this manner, the commission entering an order based on and containing the terms of the agreement, but the commission not passing on the reasonableness of the terms and rates agreed to. When there is no disposition to settle the case by agreement, and where it is a rate that is in contention, the utility is directed to make an inventory and appraisal of its property following the classification given by the commission.

The city usually puts in a valuation to support its contention, and it, too, is requested to make its valuation on the lines given in the classification. This lists the physical property of the utility under eight main heads, namely, Land, Transmission and Distribution, Buildings and Structures, Plant Equipment, General Equipment, Paving, Materials and Supplies and lastly, Non-Operating Property. Each main heading is subdivided in detail so that there is a place to put every kind of property used and useful to the utility in its business of supplying water. There is not usually much coöperation between the city and the company during the process of settling a rate case before the commission, but when both follow this outline, the valuations presented are easily compared. This saves time on the part of all concerned and as the lawyers and experts employed by each side do not work for the pure joy of it, this means a saving of money.

This classification is but the first step toward making up a set of instructions for the preparation of valuations. The different items going to make up unit costs will be set forth fully. Take, for instance, a distribution system, the main items entering are the cost of the material and the cost of placing it. The cost of material is arrived at by taking the cost of pipe, specials, valves, hydrant and lead at the foundry and adding to each the freight, handling, store-room charges and cost of hauling to the job. Under the item of labor is included cost of trenching, backfilling, placing, jointing tools and minor incidentals. Both the material and labor charge reduced

to cost per foot and added gives the unit cost of a main, and apparently there is no chance for confusion here. Going a step further, however, we often find two witnesses, both qualified to testify on overhead, may not agree at all closely as to the percentage to be applied. This difference of opinion is apparent only, for, after much examination and cross examination, it is shown that where one witness includes in his percentages the cost of engineering, superintendence, insurance and interest during construction, legal expenses and contingencies, the other is testifying to the same plus a contractor's profit. The first witness has figured his contractor's profit into his unit costs. The commission's aim in preparing these detailed instructions is to avoid just such confusion as this and thereby shorten the hearings down to a minimum, and still give each party to the controversy time to put in all testimony and exhibits pertinent to the point at issue.

A recent valuation submitted to the commission is worthy of note. As an inventory or list of the physical property it was very useful, but as a valuation it is of little help. At the first hearing it was brought out that the value placed on each item represented the utility's idea of the cost new depreciated, or present value, with an addition for overhead and going value. The attorney for the city made the company witness, the expert who prepared the valuation, admit that he knew of no other way to make one that would give less information to the commission. This, however, was not a water case, but is cited here to show what the commission considers the way *not* to present facts.

The correct compiling of financial and statistical statements from the books of the company is equal in importance to a correct valuation for rate making purposes, as a rate cannot be established with either alone. For this reason a detailed memorandum or set of instructions is being prepared directing the utility how to submit with this valuation the following statistical statement: record of gross pumpings for last five years by months, total water sold to metered consumers for the last five years, classification of consumers by amount consumed for the year, classification of private consumers by nature of premises served; also by size of meter, and lastly, flat rate consumers, fixtures installed in each premises and present income from each. Some of the more important financial statements about which detailed instructions will be given and their compilation are comparative balance sheets for the year closing on the date of the

valuation, fixed capital account as of the same date and a detailed statement of operating expenses, revenues together with income and profit and loss account for the last five years ending on the date of the valuation or any other date that may be determined by the commission. Some states have prepared and distributed such instructions for making valuations as have been described, for instance, the Ohio Commission. The staff's idea at the present time is to go quite a little beyond what the Ohio Commission has done in this matter and show the utility just how and in what order the facts should be presented. To do the work in the way the commission has asked may seem a hardship to the utility at the time the work of valuation is being carried on, but if some of the hearings now being held by the commission could be attended, and the great loss of time occasioned by the lack of coöperation or following of the same general scheme could be noted, the most critical would be fully convinced that there is a great need for a uniformity in presenting facts.

When the water and other utilities of the State were asked to file with the commission their schedule of rates, special contracts and franchises under which they operate, it was the first step of the commission toward fulfilling the function for which it was created—the regulation of public utilities. Those schedules have been gone over by the rate department and in some cases conditions found that will be remedied by the help of the commission, but which the water companies have not been able to adjust without creating unpleasant relations between themselves and a few of their consumers. Special contracts giving a lower rate to certain large consumers have in some cases been inherited by the present owners of the utility at the time the physical plant was purchased. As a privilege once obtained is soon regarded as a vested right, it is nearly impossible to demonstrate to the favored consumer that discrimination in his favor is not just. A set of instructions is now being prepared directing just how these schedules shall be arranged and just what the commission will recognize as a rate in force. As stipulated in Section 38 of our law, no utility shall grant any preference or advantage to any consumer. Standing on this and further enforced by the instructions, soon to become an order, the utilities selling water on those inherited and unjustly discriminatory contracts can and, in fact, must abrogate them and put the heretofore favored consumers on the regular rates. In this way the utility is absolved

from any controversy and the conditions are remedied to its satisfaction. One case brought to the attention of the commission showed that a water company was selling over half of its output under special contracts for a rate that did not yield a fair return on the investment and although the utility was assured of this fact, it could not seem to eliminate these discriminatory contracts because they had been in force practically ever since the plant started.

The commission is given authority to establish a uniform system of accounts, and toward this end the utilities were asked to fill out an annual report form sent out about the first of this year. In going over those reports that have come in, over half do not give the information asked for, apparently because the utilities' books are not kept in a way that will allow of obtaining the desired information. A system of accounting that would give this is absolutely essential for the most efficient operation of a plant but it is during the last few years only that water works men have begun to realize this fact. One operator at a small plant figured that he lost several hundred dollars last year because he had to put in a new boiler, but he "guessed" he would make a little money this year or next. A system of accounts has been prepared in tentative form and when put into effect by the various utilities, there is little doubt that the trouble of changing from the present method of bookkeeping, in some cases extremely haphazard, to that prescribed by the commission, will be insignificant in comparison to the benefit received.

The information that the commission will obtain from these annual reports when submitted correctly will be worked up into statistical form and can be obtained by any water utility for the asking. Each can then see just how its cost per thousand gallons pumped compares with the other companies in the State and what will be of more value, how it compares with plants operating under similar conditions. No two costs, of course, will be identical, for local conditions will influence the ultimate result, but an operator, with all these facts in front of him, can analyze his own operating costs and taking into account his local problems, can find out just how he stands. From this it can be seen just how important it is that all the information asked for be given in these reports. This first form contained several pages covering the physical property, but this will be eliminated from subsequent reports and only additions asked for.

A set of general rules for the guidance of water utilities is now being prepared by the staff. These are similar to the rules adopted by the commission covering gas and electric service. These rules will establish the allowable error on water meters, specify the equipment the water company must have for meter testing, the time that a meter can remain in service without a test, the charge the commission will make for request tests and regulations about the kind of test record that must be kept, etc. Before the commission adopts any of these service rules, they will be sent out in tentative form to the water companies and a date set for a hearing at which time any changes that are shown to be necessary by the utilities will be made. After the rules are adopted they will be published and sent out to the water companies in placard form to be posted in a conspicuous place in the business office.

The commission is trying to accomplish for the consumer a satisfactory service, for the utility a fair return on the investment commensurate with the service and a better understanding between the utility and the consumer. The latter is largely a matter of education, for the average consumer does not realize the investment made on the part of the utility to bring water into his premises and the continual outlay necessary to keep the service satisfactory. In one city there is a movement on foot to bring the question of rates to the commission with the request that they be lowered. The leaders of this movement feel the consumers should be given water for almost nothing for they say "the water company gets the water right out of the ground here in the city so why shouldn't we be given the lower rate that we ask for?"

RIVER SAND AS A FILTER MEDIUM¹

BY L. A. FRITZE²

In the selection of sands for filtration purposes, it has been common practice to use the uniform kinds usually obtained from banks or the sea coast. Bank sands are to be found in different parts of the country, yielding a product which has proved very efficient as a filter medium.

The filter plant proposing to use these screened, sharp sands, generally finds the cost very high, so high some times as to almost make its use prohibitive.

To offset this cost, other sands have come into use, and prominent among them is river sand. If a river sand can be found free from mud and other objectionable matter and of a uniform size, there is no reason why it will not give satisfaction as a filter medium. If clay, mud, etc., be present, its removal may offset the financial advantage and make the bank sand cheaper in the end.

However, in this paper, advantage will be taken of the fact that clean, uniform sand can be obtained from river beds, and our cost data will be based on this product.

In some of the older plants in this country, river sand has been in use for a number of years, with results that are very satisfactory.

In slow sand filtration and rapid sand filtration alike, these cheaper sands have been in service from seven to twelve years, and the results prove that a satisfactory effluent may be obtained.

Since the installation of bleaching powder and other sterilization agents, as an additional aid to purification, the necessity for a sand of such high merit as formerly is not now of such exacting importance. However, the size of the sand must be considered, for one too fine will clog quickly, and one too coarse will not yield a satisfactory effluent.

In rapid sand filtration, the use of river sand has become quite common. Inquiries sent to a number of these plants show that a

¹ Read at first meeting Illinois Section, American Water Works Association, March 10, 1915.

² City Chemist, Moline, Illinois.

very satisfactory water has been obtained with a sand one-fourth the former cost.

In Moline and Rock Island, the experience has been the same. River sand has been in service for two years with results which indicate its permanent use. This sand is obtained from the Mississippi River, above the city of Moline. A local sand company supplies the material, collecting it in the following manner. By means of a centrifugal sand pump on a boat, a barge is loaded. This barge is then unloaded at the docks of the company by a stream of water from the sand pump, into the river again. After emptying the barge, the sand is then taken from the river and pumped into the sand bins. By this means of unloading, the sand is thoroughly washed and freed from objectionable matter.

This raw, unscreened product has an effective size of 0.28 mm. and a uniformity coefficient of 2.11. When placed in a filter, the fine powder will find its way to the surface during washing. Unless this powder is removed, the filter will clog very quickly and necessitate an increase in wash water. By scraping the bed and freeing the sand of this material, a medium will be obtained with an effective size of 0.51 mm. and a uniformity coefficient of 1.34. For filtration purposes this sand is very efficient.

The loss due to the discarding of the fine powder will vary with the different sands, ranging from 5 to 40 per cent. The Mississippi sand contains about 5 per cent fine powder, which is very easily removed by washing.

It has been found that the size of gravel used will effect the results obtained with river sand. Small gravel $\frac{3}{4}$ -inch to $\frac{1}{4}$ -inch was in use for a year, but the results show that larger gravel is needed.

To meet this, gravel 2 inches and over was placed next to the strainers to a depth of 9 inches. With the smaller gravel on this bed and the sand on top, conditions are very satisfactory. This filter has been in service six months and to date there has been no packing and strainer trouble.

Likewise in Rock Island, it was found necessary to supplant the fine gravel with the larger material, when the river sand was employed. Using the larger size gravel has eliminated considerable of their trouble.

The financial saving of the river sand over the more expensive bank sands is considerable. The cost of the Mississippi River sand per cubic yard delivered to the filter plant is 70 cents. The loss in

this sand due to the fine powder is 5 per cent, making the actual cost per cubic yard 72.9 cents.

Large gravel to the depth of nine inches is needed to obtain satisfactory results. This quantity represents about nine cubic yards and costing \$2.35 per yard, totals \$21.15. This cost must be added to that of the sand.

The wash water required to free the sand of the fine powder is 125,000 gallons and costing one cent per 1000 gallons, totals \$1.25.

Considering these additional factors, the cost of the river sand ready for service in the filters is \$1.47 per cubic yard.

For comparison, selecting a well known bank sand, commonly in use in this section of the country, that from Red Wing, Minnesota, the best grade of filter sand obtained at this place costs \$3 per ton or \$4.05 per cubic yard. The freight from Red Wing to Moline is \$1.80 per ton or \$2.43 per cubic yard, making a total cost per cubic yard, delivered to the filter plant, of \$6.48. An additional charge of 25 cents per yard must be made for unloading, bringing the total cost per cubic yard to \$6.73.

Using the two figures for sand costs as found at Moline, the river sand shows a net saving of \$5.26 per cubic yard over the Red Wing bank sand. Thirty cubic yards of sand are needed per filter to make the medium the proper depth, and with the above figures the saving per unit is \$158 or \$789 for the five 1,000,000 gallon units in the plants.

It has been found that the yearly loss of sand due to various causes is about one cubic yard per filter. With river sand this means an annual loss of \$3.65, with bank sand \$33.65, or a net saving of \$30 per year, using river sand.

Cost records on the cleaning of filters, that is, the removal of the sand and gravel, and the cleaning of the collecting system, show that 120 hours time is necessary for the work, and the expenditure \$30. In other words, one unit can be cleaned and the lost sand replaced in the other units for the same amount of money as needed for only replacing the lost bank sand.

It may be said in conclusion that river sand is being used with satisfactory results in a number of filter plants, that the cost is much less than the average bank sand, and that the water works proposing to buy new sand can well afford to investigate the quality and quantity available in their own locality, before purchasing.

WASH WATER SALVAGE AT CHAMPAIGN AND URBANA¹

BY HAROLD E. BABBITT

The public water supply of the cities of Champaign and Urbana is obtained from deep wells located in the northern section of Urbana. The water is pumped into a collecting reservoir and thence passes through an iron removal plant of the rapid sand filter type, with a nominal capacity of 2,000,000 gallons per day. No chemicals are used in the process of iron removal, aeration being sufficient to cause the precipitation of the iron. Much of this precipitated matter is caught on the sand grains of the filter, and, because of its tenacious or gelatinous qualities, causes difficulties in the operation of the filters. Wide and deep cracks formed in the filtering material similar to mud cracks seriously affect the quality of the effluent from the plant and necessitate the use of large quantities of wash water. A complete description of the iron removal plant of the Champaign and Urbana Water Company was presented before the Illinois Water Supply Association last year, by Professor Talbot.

During the summer of 1914 the amount of wash water used at the plant was estimated at anywhere from 6 per cent to 20 per cent of the nominal capacity of the plant. A figure in the neighborhood of 8 to 10 per cent is probably a fair value. The loss of 150,000 to 200,000 gallons of water per day is equivalent to a little more than the output of one of the wells from which the water is taken. On the basis of the rates charged the consumer for water, it amounts to about \$3750 per year. The cost of a well complete for service is about \$2000. An appreciable financial outlay would be justified which would save a large portion of this water.

The idea was conceived that by collecting the used wash water in a sedimentation basin the greater portion of the matter removed from the filter would settle out and the water be usable again. As a result a reservoir with a capacity of 90,000 gallons was constructed

¹ Read at the first annual meeting of the Illinois Section, American Water Works Association, March 10, 1915.

in the fall of 1914 and put into immediate use. The cost of this reservoir was \$1987, including pump, motor and pump house. This represents a saving over the construction of a new well at the same initial cost, in that the operation, maintenance and depreciation on the reservoir are less than that for a well. The reservoir is successful in saving all but about 16,000 gallons per day, and represents an appreciable financial saving. The financial advantage is enhanced by the greater amount of water rendered available, not always an easy factor to obtain at any cost.

The wash water reservoir is a reinforced concrete structure with monolithic walls. It is rectangular in plan with a depth of about 12 feet, almost entirely in excavation. The location of the reservoir is such as to cause difficulty in its construction. It is six feet south of the collecting or raw water reservoir which was disturbed in making the new excavation. This necessitated extra precaution in the amount and the strength of the form bracing. The difficulties and haste of construction account somewhat for the relatively high cost.

Since its construction the reservoir has withstood the difficult conditions of filling and emptying twice daily in all weathers without signs of deterioration, leakage, or weakness—other than a crack in the floor above the end of the inside footing of the wall next to the collecting reservoir. Indications are that this crack is due to unsatisfactory foundation conditions. Imperviousness in the concrete was sought by making a dense mixture in the proportions of 1 cement, 2 sand, and 4 stone and applying two coats of Ironite after the setting of the concrete. The character of the water is such, however, that no provisions for this purpose were necessary. Cracks of large size would immediately be filled by a gummy deposit of iron successfully stopping them from the passage of water.

The reservoir receives the wash water discharged from the filters at the two daily washings at 8 a.m. and at 4 p.m. The water for washing is drawn directly from the clear water basin and discharged into the filters by an 8-inch centrifugal pump. After passing through the filter the wash water is dosed with 2 grains of alum per gallon, roughly measured, and passes to the wash water reservoir where it is allowed to stand for about two hours. Clarification is rapid, but all the time available for settling is made use of. The supernatant liquid is pumped from the reservoir through a floating suction pipe into the collecting reservoir. Six to twelve inches of slushy material

are allowed to waste into the sewers after each pumping. The actual amount of wash water entering the sewers is thus about 0.8 per cent of the capacity of the plant. The amount of water used in washing the filters is about the same as before the installation of the wash water reservoir.

The effect of settling the water without the use of a coagulant was tried. It was found that about 18 hours settling were required before the water could be pumped back into the collecting reservoir. As better results were obtained from the filters by two washings per day, coagulant was applied to accelerate the rate of sedimentation. The effluent from the coagulated water is clearer than from the non-coagulated, but it seems no easier to handle in the filters.

The effect on the filters of passing the settled wash water mixed with raw water through them has been to increase the loss of head after washing from 14 or 18 inches to 24 or 36 inches, and the head loss before washing from 40 or 60 inches to 48 or 72 inches. The character of the effluent is not detrimentally affected.

In the discussion of Professor Talbot's article, last year, Mr. W. W. De Berard suggested that some of the difficulties encountered by the necessity for frequent washing of the filters with a fire hose or by other laborious means might be overcome by using an additional wash water manifold immediately above the sand layer. Such a grid was constructed by Mr. W. I. Ainsworth, operator of the plant, of old material on hand, supplemented by a few new fittings. The grid is made up of a two-inch wrought iron pipe manifold with $\frac{3}{4}$ -inch branches on 11-inch centers. One-eighth inch holes on 5-inch centers are bored on the under sides of the pipe and manifold. The grid covers only one-half of the area of the filter, but because of the clogging of the $\frac{1}{8}$ -inch holes by the iron deposits only one-quarter of the area of the filter is affected by the grid. The result, however, has been to obviate the necessity of washing this unit with a fire hose. The loss of head on this filter after washing will increase from 18 inches to 24 inches, in the same time that the adjacent units are increasing from 18 inches to 52 inches. It is planned to install similar grids with $\frac{3}{16}$ -inch holes on all the filters.

DISCUSSION

MR. W. W. JENNINGS: Does the reservoir have a hopper-shaped bottom and how often is it washed?

MR. BABBITT: The bottom of the reservoir is a single plane surface sloping from a depth of 12 feet on one corner to a depth of 13 feet on the diagonally opposite corner, a distance of about 40 feet. The reservoir is drained after each washing, the total amount of water entering the sewers being about 0.8 per cent of the capacity of the plant.

MR. W. W. DE BERARD: Before finally putting the auxiliary grid in all of the filters further experiments should be made to learn the maximum spacing permissible between orifice opening and between laterals. Mr. Babbitt reports that the whole filter needs no hand hosing, although one-half of the surface only is covered and further only one-half the holes in this grid are open. It was the intention at Oakland, where we carried out the original experiments for the People's Water Company, to ascertain this point but we never got that far. Would it not be the logical thing to double up the distance between laterals and increase somewhat the orifice openings? This will cheapen the grid cost and make it more likely to be tried elsewhere. It is pleasant to learn that the results of experiments carried on eight years ago are being made use of with such good results.

In passing it may be said that we tried pointing the jets in all directions. When directed in any but downward, sand was shot out over the edges of the gutter. Not much added impetus is required to project a sand grain to the gutter under such condition.

This means of applying the wash water is the only one which the speaker knows that will allow one to take advantage of the jet action, and thus to produce the attrition of one sand grain against another. No filter strainer made produces a jet action more than a very few inches from the orifice. It would be a detriment to the system if it did, for the action would be taking place on clean sand grains. To make jet action effective it must be applied at a point where the dirty sand lies at the top of the bed.

WASTE PREVENTION BY INDIVIDUAL METERS VERSUS DISTRICT METERS¹

By R. O. WYNNE-ROBERTS

There are many cases where it would be difficult to make an equitable charge for water consumed unless the quantity was measured. These are industries, institutions, premises requiring water in very small quantities for sanitary purposes and large consumers. But the large majority of consumers do not actually need much water, although it is well known that an inordinate quantity is used or misused. This has arisen in some instances from the fact that it was considered more economical to supply than to check, in other cases it is due to indifferent management and neglect until the waste has created serious disabilities on the part of some of the water authorities.

There is now a general movement for the conservation of water and the principal means taken is to install individual meters on all water connections. The object of this short paper will be to discuss the question as to whether the general installation of individual meters or the provision of district meters is to be advocated.

Waste of water must be eliminated as far as practicable and economical, for the keynote of successful management of all business is to stop leaks of all kinds.

A water works system loaded with a high rate of supply is not unlike a ship which has a constantly leaky water ballast, for neither the water works nor the ship can be operated to its full legitimate capacity, nor made to be revenue producing to the extent it should. The proprietors of the water works who propose to install a general meter system so as to reduce some of the leaks may be compared with the shipowners who have some of the leaks in the ship's hull repaired and pumps provided to reduce the water ballast. Carrying the analogy still further, the water works proprietors who install bulk and district meters, a few individual meters and by means of efficient inspection reduce all leaks to a minimum are similar in

¹ Read at first annual meeting Illinois Section, American Water Works Association, March 10, 1915.

purpose to the shipowners who have the ship's hull thoroughly overhauled, and ample pumps provided to keep the water ballast empty. In both these cases the property is maintained in an efficient condition and made to produce the maximum revenue at the minimum cost.

Most of the cities are relatively small and if it be assumed that the average size is about 20,000 population, it will doubtless represent a large number of towns. The unrestricted total consumption is say 150 gallons per head daily. In such a city there would be about 3500 water connections and if all are metered there would be that number to fix and maintain. The water authority to secure full control over the meters would buy the meters and rent them out.

Adopting the careful analysis of costs made by the Wisconsin Railroad Commission and mentioned in their report of 1911, the average annual cost is as follows:

Labor moving and resetting meters.....		\$0.18
Labor meter and fittings department.....		0.34
Supplies, meter and fittings department.....		0.12
Maintenance of meter.....		0.35
Reading meters and delivering bills.....		1.35
		2.34
To these must be added		
Depreciation, say.....	\$0.50	
Interest.....	0.36	0.86
Per meter per year.....		\$3.20

The cost of metering will fall on the consumers and in this case it would amount to \$11,900 per annum.

The cost of filtered water at the works will be about \$3.50 per million gallons.

Individual meters measure the water entering the premises and consequently constitute good waste detectors. The saving in the quantity of water used before and after installing meters varies greatly, but in all cities metering has effected a tangible reduction in the quantity of water pumped. Published figures are often misleading because the diminution in the quantity consumed by the people is often small compared with the losses on the mains. When the total quantity of water registered by individual meters is ascer-

tained, the unaccounted for losses amount to from 20 to 66 per cent of the total quantity pumped. It will be fair to expect 33 per cent reduction in the pumpage by universal metering. Supposing the head on the pumps is 100 feet and price of coal is \$4 per ton then the saving in fuel due to diminished pumpage will be about \$1200 per annum. The cost of labor will remain practically the same.

District meters could be installed in this city for about \$3000, a small number of individual meters would be required as explained in the commencement, and inspectors would be employed to make a systematic and frequent survey of the whole water works. The annual expenditure in this case would be as follows:

Interest on \$3000.....	\$150	
Depreciation.....	150	\$300
2 inspectors.....	\$2500	
Clerks, etc.....	1500	
		4000
250 meters at \$3.40.....		850
Miscellaneous.....		250
Total.....		\$5400

By careful and diligent inspection the pumpage should be gradually reduced to one-half and the saving in fuel on the same basis as before would be \$1800.

The above estimate is liberal. The writer had control of water works and by means of this method was able to supply the public on less than 30 gallons per head daily for all purposes, the railroad companies were large consumers. The London Water Board use from 1300 to 1400 Deacon meters to detect waste and by discovering and localizing leaks the average supply is under 45 gallons per head daily. By means of pitometer survey at Ottawa, Canada, leaks amounting to 5,300,000 gallons per day were remedied in a short time. Washington has in seven years detected leaks aggregating 40,000,000 gallons daily. Three permanent self-recording district meters have been installed in Regina, but systematic inspections have not yet been started. The record obtained from the district meters enable the officials to detect leaks and to localize them and by this means keep the consumption at a reasonable figure. Such meters and records are a check on the pumps and on the daily occurrences in the district controlled.

The reduction of waste is equivalent to increasing the capacity of the water works to meet growing demands and at a reduced cost or with increased revenue.

Even in cities where the rate is fixed by the Public Utility Commissions and individual meters are compulsory, district meters are essential to provide an efficient and economical system. With both individual meters and self-recording district meters the quantity of water necessary to satisfy all requirements should not exceed 50 gallons per head per day, except in special cases where the industrial consumption is abnormally high.

The financial situation as estimated in the foregoing illustrations will be as follows:

Individual meters

Cost of operation.....	\$11,900	Saving in fuel.....	\$1200	
		Value of water		
		saved.....	\$1277	\$2477

District meters

Cost of operation.....	\$5,400	Saving in fuel.....	\$1800	
		Value of water		
		saved.....	\$1914	\$3714

It will be observed that in the case of individual meters the estimated cost of operation and the savings effected is about \$9423, which is equivalent to about \$2.70 extra cost per water-paying consumer per annum, whilst in the case of district meters the corresponding figures are \$1786 and 52 cents respectively.

BUBBLY CREEK FILTER PLANT ADOPTS LIQUID CHLORINE TREATMENT¹

BY C. A. JENNINGS

It is interesting to note that seven years ago water purification was accomplished by storage or sedimentation alone or in conjunction with filtration. There were no supplementary purifying processes, such as disinfection, that were on a practical working basis. Today the water works engineer has the choice of two or three supplementary processes, viz., hypochlorite, liquid chlorine and possibly ultra-violet rays. The first two are well established. The third, although it is possibly more practical than ozone at this time and although it has been given serious consideration recently by two or three cities, nevertheless is not yet on an established working basis.

The Bubbly Creek filter plant at the Chicago stock yards set the lead in the use of hypochlorite of lime in this country for water disinfection. This was during the summer of 1908. Several years ago experiments were begun at this plant with an electrolytic cell for the production of chlorine from salt brine. These experiments were carried out very extensively and thoroughly. The writer finally concluded that in comparison with hypochlorite and liquid chlorine, the production of chlorine for water disinfection by means of an electrolytic cell was expensive, uncertain and demanded considerable attention.

Very recently a liquid chlorine apparatus was purchased. Chlorine is received in cylinders that hold 105 pounds of the liquefied gas. From the experience gained by operating this apparatus during the past month, the writer has concluded that, in comparison with the use of hypo at the Bubbly Creek filter plant,

1. There is considerably less labor involved.
2. The absorption of the gas by the water is more rapid.
3. There is no loss of chlorine and smaller quantities can be used to accomplish equivalent results.

¹ Read at first annual meeting Illinois Section, American Water Works Association, March 10, 1915.

4. There is no deterioration of the chlorine in the cylinders while using or while stored.

5. The changing of the rate of application is easily, quickly and accurately accomplished.

6. There is no odor of chlorine about the plant.

7. The cost is considerably less.

There are mechanical features about the Bubbly Creek filter plant which the writer believes are peculiar to it. These features are the enormous amount of hypochlorite necessary to disinfect the water, the poor mechanical means for getting into solution all of the hypochlorite used, which resulted in a large loss of available chlorine, and the last pertinent feature, the irregularity in the operation of the plant due to a varying consumption and small filtered water storage capacity. This often caused it to be necessary to run one or two filters for a time and then suddenly have to use eight filters. Naturally the coagulant and germicide must be proportioned to the amount of water being filtered. Now while using liquid chlorine, the regulation of the germicide is much more simple, accurate and economical than with hypo. The ratio of costs, during one month's operation with liquid chlorine with an average raw water supply and the treated filtered water as low in bacteria as when using hypo, was 1 to 3 in favor of liquid chlorine. It is hardly probable that every plant will show such a large difference in the costs of disinfection by the two methods.

DISCUSSION

MR. H. E. JORDAN: While the average plant using chlorine in some form as a sterilizing agent will not effect the saving noted by Mr. Jennings, the cost in any case will not effect the material advantages gained in ease of operation and freedom from odor.

Water works men have become accustomed to installing hypochlorite outfits in a very crude way, at a low cost. These installations need to be frequently replaced. So in considering the installation of a liquid chlorine plant, many will object to the comparatively large initial outlay. The liquid chlorine plant can be installed in an open pump room or even a plant office, without bad effect upon copper alloy or offense to the persons working there. The improvement in the mental attitude of the employees is a very great item in favor of this method. At the same time, liquid chlorine plants,

while nominally automatic, need attention not only when changing tanks, but under normal conditions the responsiveness of the feed regulation device should be frequently tested. This is no more than is the case in running pumps or any other piece of water works machinery, and is not to be held as a disadvantage of a liquid chlorine plant.

The experience at the East Chicago plant, over a period of a year, is that the system is doing all that could be expected of it in its effect upon the water, and that it operates satisfactorily under conditions that are well nigh impossible of handling with a hypochlorite plant.

C. A. JENNINGS: In order to aid somewhat in analyzing the deductions made as to cost data, it might be added that the liquid chlorine costs us 8 cents per pound f.o.b. Niagara Falls and the freight rate is sufficient to bring the cost to $8\frac{1}{2}$ cents per pound delivered in Chicago. The last carload lot of hypo purchased cost $1\frac{1}{4}$ cents per pound f.o.b. Chicago. The rate of application of hypo has been from 50 pounds to as high as 100 pounds per million gallons. Remarkable as it may seem, the saving in the cost of treatment by liquid chlorine over hypo is sufficient at the present rate to pay for the liquid chlorine apparatus in 100 days.

EXPERIENCES IN REBUILDING AND REËNFORCING A WATER WORKS SYSTEM¹

By O. T. SMITH

It may be well to state, in the beginning, some of the conditions under which the work was done so that a better understanding may be had of the situation. The franchise of the Water Company expired July 1, 1912, and negotiations were begun for a sale or a renewal of the franchise a year and a half previous to that date. The Chamber of Commerce of the city was brought into the negotiations by the city council agreeing to the appointment of a committee of ten of the members of the association to assist the city council in the purchasing of the plant or in passing a franchise. Arrangements were made to proceed under the clause in the franchise which gave the city the right to purchase at its expiration. The preliminary negotiations showed that the city had no power to purchase, but it was agreed that there should be a valuation of the plant, proceeding as though the city could purchase. It was further agreed that the commission required by the franchise should be requested to suggest a proper ordinance which of course included the suggestion of fair rates.

The appraisal was made and the commission's valuation was accepted by both the city and the company. The proceedings of the commission were considered entirely fair by both parties. The city selected an eminent engineer, Mr. F. E. Tuneaure, Dean of Engineering of the University of Wisconsin. The water company chose Mr. John W. Alvord, of Chicago, and the two agreed upon Dean Marston, of the University of Iowa, as the third member of the commission. The commission was required also to outline the necessary improvements and make an estimate of the cost of the said improvements, to place the plant in proper condition to give adequate fire protection and private service for a period of years, the whole to be made a basis for fixing rates and charges.

¹ Read at first meeting Illinois Section, American Water Works Association, March 10, 1915.

Previous to the beginning of the negotiations the company had prepared an inventory of its property under the direction of Mr. Dabney H. Maury. This inventory was accepted by the commission together with a supplementary inventory covering the two years subsequent to Mr. Maury's inventory, made by the city engineer and the writer together. The commission estimated the cost of additional improvements and extensions at \$182,000 by the end of 1916. The ordinance as finally passed included these improvements and extensions as a condition of the extension of the franchise for thirty years.

The improvements outlined by the commission were additional high service and low service pumps, additional filter plant, additional boiler capacity, additional storage reservoir, and additional water supply, together with about thirteen miles of mains for the reinforcement and extension of the distribution system. This work was begun in the fall of 1912. Pumps were contracted for, cast iron pipe was purchased, and the work progressed to final completion in the fall of 1914. The work of connecting the new pumps with the old system and the many necessary connections at street intersections were interesting, and, frequently, rather complicated propositions. In most cases the street intersection connections were made by using a cross with a valve on each side of the old main, using a Smith style tapping machine for the work.

In the improvements required were two new river crossings, owing to the fact that the great factory district was on the easterly side of the river. One crossing was a 10-inch and the other an 8-inch. These were in addition to one 8-inch crossing which was in the original plant. To facilitate the work of laying mains the company concluded to purchase a trench machine and decided upon a second-hand machine which paid for itself in the two years operation, several times over. As an indication of the value of this machine; at one time the machine was out of commission for four days and in order to complete an extension before cold weather the gang of men were kept and did the digging by hand. During four days until the machine was again in commission with hand labor with the same number of men, exactly the same amount of pipe was laid that was laid in one day after the machine was again in use. Of course, all situations did not show such results, but there were enough of such jobs to make the purchase of the machine very economical. In making the river crossings a universal joint was

used. Of course, this is not new to you but is of interest, as to the manner in which a small river crossing can be made successfully.

In addition to the work which was specifically mentioned and required in the ordinance, the city under its right to order further extensions, exercised that right frequently during the period of construction, and during the two years and a half which have elapsed the city has ordered and the company has laid about four miles of extra extensions. The basis on which the city may order an extension is considered a fair one. The requirements of the ordinance covering the reënforcement of the system, practically entirely for fire protection, were that the city should pay a certain fixed sum for fire protection covering the improvements, additions, and extensions specifically named in the ordinance, and for additional extensions by the payment of an annual rental of as many cents per lineal foot as equals one-half of the diameter of the pipe in inches plus a specific price for each hydrant placed on such extensions. For instance, if the city orders an extension of 500 feet of 6-inch main and a hydrant, they would pay \$15 per annum for the mains and \$7.50 per annum for the hydrant. This arrangement has resulted in the city freely ordering extensions where called for by prospective private consumers; and the cheapness of the hydrant rental has resulted in a much more frequent spacing of hydrants which is required by the ordinance and is very desirable.

The financial result under this ordinance has been satisfactory. The changing from flat rates to meters has increased the revenue substantially, while the pumpage has decreased, not to a very remarkable extent, but during the year 1914 the pumpage was less than in any year during the three years previous.

The rates on meter bills are figured by the hundred feet and the maximum rate is for the first 2000 feet per month. The next 3000 feet is at a lower rate and all over 5000 feet is at another rate so that every consumer gets the same rate for the same amount consumed, and the more he uses, the less the rate, automatically.

EXPERIENCE WITH ARTESIAN WELL WATER AT ELGIN, ILLINOIS¹

BY R. R. PARKIN

In 1903-1904 the city of Elgin installed four artesian wells. One 2005 and three 1300 feet deep, and after the wells were completed, a shaft 9 feet in diameter was sunk 115 feet deep. At this depth tunnels 5 feet in diameter in opposite directions were run for about 500 feet, connecting the wells and piped each with 12-inch pipe which are run through the tunnels to central shaft and connected to pumps at the bottom of the shaft. These tunnels are built of concrete and very successfully shut out all seepage into the tunnels.

The wells are as near as possible in a direct line from the shaft. After the shaft and tunnels were finished, each well was plugged below the line of the tunnels with a rubber disc held in place by 2-inch pipe from the surface, shutting off the water below the line of tunnels where a 12-inch disc was cut out in the 12-inch well pipe. On this 12-inch pipe was attached a 12-inch split sleeve to each well pipe. A 12-flange valve was also attached, and from each well was connected 12-inch cast iron flanged pipe back to the shaft and pumps.

In sinking this shaft a great amount of water was encountered which resulted in one contractor abandoning the work. After some delay the work was let to another firm who nearly completed it. After some further delay it was decided to assume and complete the work as designed, which was quite successful. This vein of water referred to, coming from the hillside and flowing towards the river, was estimated from 800,000 to 1,000,000 gallons per day. The contractor used every means of his own to keep the water out. During this time, for several days, quite a flow of sand was noticed coming in with the water, which was being raised out in buckets and pump. Warning was given them to stop this flow of sand or stop the work. This was not taken seriously and they

¹ Read at first annual meeting Illinois Section, American Water Works Association, March 10, 1915.

continued until about 3 a.m. when one of our engineers said there was a leak in the filter house. The contractor was at once ordered to stop work immediately. At the station it was found that two filters were out of line. All the damage done was the breaking of a 7-inch flange on one of the filter lines.

After this the work was done under air pressure of about 16 pounds down to about 65 feet, where blue shale was found and no water. Several 4-inch bleeders had been placed in the cement near this water vein, so that in the future they could be connected with our well system and this water used, but as this vein of water was carrying a large amount of quicksand with it, and had undermined the foundations of filters and buildings, it has not been made use of.

The cement was very successfully gotten into place. The air pressure was kept on for about eight days. When the air was released, very little if any water came through the concrete, and the shaft is quite dry at this time. From this time to 1913 this vein of water has been in our minds as an additional source of supply.

Elgin, like most cities, is growing, and its demands for water increase, and have to be satisfied. In 1913 we were obliged, for the first time in twenty-five years, to restrict our consumers in the use of water for outside use. This called attention to the need of increase of our supply, and after advertising and receiving bids for a deep well, which were quite in excess of former bids received in 1904, it was decided to go after this water referred to, and a local well-driller was employed to, if possible, find the vein. One 6-inch hole had been drilled to bed rock; the first drilled being below the reservoirs some distance from the station. In this hole the water did not rise on reaching the limestone. This was rather an experiment, being about 1000 feet from our shaft.

At the second location being quite sure of finding water, and after drilling into the same limestone which underlies our city, water was found which rose about 26 feet above the limestone in the 6-inch pipe. The temperature of this water was 54 degrees.

Several tests were made by pumping from the surface and at 12 feet below. In the tests it was found that 125 gallons could be raised per minute, lowering the head only a few inches. This was done by weir measurement, and with a larger pump 240 gallons per minute were raised under the same condition. With these results it was decided to sink a shaft of about 6 feet in diameter, starting with a square hole to water line. At this line a platform was built

upon which was installed a larger pump driven by 12 h.p. motor, belt connected. This for some days kept the water down so that the men made rapid progress for about 10 feet, mostly in clay. At this depth the pump failed to keep the water down, and another one was procured. After this the work progressed very fast until near the depth of 33 feet when the water increased above the capacity of the pump, and a pulsometer pump was procured, and with the two the water was kept down from the water line. Interlocking steel sheeting was used driven by a piece of railroad iron connected by cable to our hoisting engine. At times when this was hard to drive, a water jet made the driving much easier. Stones were also removed by jetting. It was quite necessary to keep the sheeting 2 or 3 feet below the digging. When too near the bottom the water pressure from below would burst through and choke the suction. The steel sheeting was driven into the limestone which is quite soft and full of water veins, through which the water boiled. After removing several feet of this limestone below the sheeting, a tier of tiles was put in around the bottom one, leaving one out every three feet; where a short piece of 6-inch pipe was used. After these were placed the hole was lined with wooden sheathing allowing a 6-inch space between, which was filled with cement under water through a 4-inch conductor pipe. In this way the cement remained with the mixture. This was carried to above the water line. Up to this line the shaft is round 5 feet 8 inches internal diameter; above this it is 6 feet square. All surface water is entirely shut out. After this shaft was completed one 600-gallon centrifugal pump was purchased. To this we have a 20 h.p. Jenny vertical motor installed at the surface. From tests made since, it shows the pumping to be about 600 gallons per minute, and from present indications will continue to be so, as the head remains about the same.

The analysis of this water made by the State Water Survey pronounces it a very good water.

THE POSSIBILITY OF AN IMPROVED WATER FROM DEEP WELLS IN NORTHERN ILLINOIS¹

BY C. B. WILLIAMS

The geology of Northern Illinois is fairly well known from the numerous wells drilled throughout this district, but the quality of the waters supplied by various strata of water-bearing rock has not been so well investigated. Most deep wells throughout this territory supply a water which is a composite, being a mixture of all good and bad water encountered in the sinking of the well.

The distinction between good and bad is not made from a sanitary stand point, as most of the deep well supplies are of unquestioned hygienic purity, but rather from their suitability for commercial and domestic purposes. Nearly all of these waters are unsatisfactory for boiler and laundry uses, as they are extremely hard and often contain objectionable iron salts.

In making a selection among the various strata of water-bearing rock, it is apparent that the lime rock may be eliminated as a medium for producing a soft water, hence we necessarily turn to the two sand rock strata as being the only possible source for a satisfactory water. A study of the general formation of these strata, the nature and conditions of their source of water supply gives a clue to the probable kind of water we may expect to obtain from each.

The Potsdam sandstone lies just above the Archean bed and varies in thickness from a few hundred to over 1500 feet, and is interspersed with layers of limestone and shale. Lying over the Potsdam sandstone is a rather thin, generally impervious blanket of limestone known as the Lower Magnesium. Over this limestone is the St. Peter sandstone usually several hundred feet thick, which in turn is overlaid with the Trenton limestone, Hudson shale and Niagara limestone successively, the latter two having been eroded in the central part of the field.

These successive layers of rock rise gradually toward the north

¹ Read at first annual meeting Illinois Section, American Water Works Association, March 10, 1915.

and west and outcrop in Wisconsin, Minnesota and Northern Michigan. The Archean rock outcrops the furthest north, in a broad irregular area, extends as far south as Chippewa Falls and Wausau, Wisconsin. South of the Archean rock is the Potsdam outcrop in a V-shaped belt covering about 14,000 square miles, the apex of the V extending as far south as Madison, Wisconsin. Next south is an outcrop belt of Lower Magnesium limestone and southerly of this is the outcrop of the St. Peter sandstone in Southern Wisconsin and Northern Illinois, having an area of about 2000 square miles.

These outcrops mostly covered with a pervious blanket of soil and gravel are the intakes so to speak of these sandstone underground channels. The general surface drainage of the main part of this territory of Wisconsin is south and southwesterly, hence the numerous streams crossing the Potsdam outcrop rise in and flow over Archean and sand rock and are less liable to become charged with lime and magnesium salts; on the contrary the streams feeding the St. Peter sandstone have previously traversed the limestone district of the Lower Magnesium outcrop, thereby becoming impregnated with the hardening salts of lime and magnesium.

These observations would lead us to believe that the Potsdam sandstone would furnish a softer water in general than that from any other strata, and as a verification of this, the results obtained from some wells sunk in Cook County are of interest.

The Chicago, Milwaukee & St. Paul Railway Co. and the Chicago and Northwestern Railway Co. have both successfully improved their water supply for boiler purposes, by casing off portions of the waters in their wells. Also the village of Western Springs has sunk a deep well and cased out certain waters, thereby greatly improving its supply, but not to the same extent as in the case of the railroads.

The Milwaukee wells are located on the Chicago and Council Bluffs division, about two miles west of Mannheim. There are at least five, the records of which are available, and all of which show similar characteristics.

The log of well No. 1 following, is typical:

Ground level 679 feet above sea level

		<i>feet</i>	<i>feet</i>
Niagara limestone.....	from	62 to	260
Hudson shale.....	from	260 to	455
Trenton limestone.....	from	455 to	785
St. Peter sandstone.....	from	785 to	1060
Lower magnesium limestone.....	from	1060 to	1262

	<i>feet</i>	<i>feet</i>
1st Potsdam sandstone.....	from 1262	to 1450
Limestone, shale, etc.....	from 1450	to 1705
2d Potsdam sandstone.....	from 1705	to 1804
Limestone.....	from 1804	to 1820
3d Potsdam sandstone.....	from 1820	to 2290

Caves were encountered at 570 feet to 590 feet, 1060 feet to 1070 feet and 1085 feet to 1095 feet. These caves were taken care of by casing. The lower and third Potsdam sandstone is composed of beds of different thickness, color and hardness.

The well is cased from the surface to a depth of 1262 feet where the casing is sealed to the rock walls by concrete.

The following are analyses of the water at various depths below the casing, given in grains per gallon:

Depths (feet).....	1450	2030	2128	2290
Oxides.....	Undeter- mined	Undeter- mined	Undeter- mined	Undeter- mined
Calcium carbonate.....	2.94	5.34	6.64	10.22
Calcium sulphate.....	4.61			3.95
Magnesium carbonate.....	0.27	2.10	2.87	3.88
Incrustating solids.....	7.82	7.44	9.51	18.05
Alkali carbonates.....		7.81	8.92	
Alkali sulphate.....	7.47	10.50	4.82	3.17
Alkali chlorides.....	3.38	4.68	12.44	50.96
Non-incrustating solids.....	10.85	22.99	26.18	54.13
Total.....	18.67	30.43	35.69	72.18

This well which is the deepest, shows a large increase in incrustating solids toward the bottom, and also a large increase in salt contents. This was avoided in the other wells of the series by lessening the depth by about fifty feet. The yield of these wells varied from 130 to 170 gallons per minute.

The Northwestern Railway drilled a chain of wells at Proviso, Cook County, Illinois, on the Galena Division, about four miles south of the Milwaukee wells. These wells were spaced from three to six hundred feet apart, and all showed similar characteristics as to depth of strata and as to quality of water. The log of well No. 3 is typical.

Surface of ground, elevation above sea level 645 feet

	<i>feet</i>	<i>feet</i>
Niagara limestone.....	from 73	to 245
Hudson shale.....	from 245	to 478
Trenton limestone.....	from 478	to 810
St. Peter sandstone.....	from 810	to 1010

	<i>feet</i>	<i>feet</i>
Lower magnesium limestone.....	from 1010 to	1220
Sandy shale.....	from 1220 to	1320
1st Potsdam sandstone.....	from 1320 to	1520
Limestone.....	from 1520 to	1747
2d Potsdam.....	from 1747 to	1830

Caves were encountered here only between the St. Peter sandstone and the Lower Magnesium limestone. This well was cased to a depth of 1690 feet and was only drilled to a depth of 1830 feet. The following is an analysis from the water at that depth given in grains per gallon:

Calcium carbonate.....	4.20
Magnesium carbonate.....	1.46
Iron and aluminum.....	0.06
Silica.....	0.46
Incrustating solids.....	6.18
Alkali chlorides.....	4.10
Alkali sulphates.....	4.04
Alkali carbonates.....	10.08
Non-incrustating solids.....	18.22
Total.....	24.40

This well, as the others in the series, was cased to a greater depth than the Milwaukee series on account of the poor quality of water found in the first Potsdam sandstone. The yield varied from about 60 to 150 gallons per minute, and the pumping of two alternate wells 600 feet apart to a depth of 242 feet lowered the water in the third intermediate well 97 feet.

The village of Western Springs, Illinois, has just completed a well in which the results obtained conform generally to those found in the Milwaukee and Northwestern wells.

This well is ten miles due south of the Milwaukee well in the township of Lyons about one-half mile from the west line of Cook County.

The following is a log of this well:

Surface of the ground, above sea level, 648 feet.

	<i>feet</i>	<i>feet</i>
Niagara limestone.....	from 73 to	360
Hudson shale.....	from 360 to	474
Trenton limestone.....	from 474 to	790
St. Peter sandstone.....	from 790 to	1244
Lower magnesium limestone.....	from 1244 to	1337
1st Potsdam sandstone.....	from 1337 to	1490
Limestone.....	from 1490 to	1765
2d Potsdam sandstone.....	from 1765 to	2046

This well was cased down to a depth of 1765 feet as the water from the first Potsdam and underlying limestone was very unsatisfactory, as may be seen from the following analyses, given in grains per gallon:

	<i>Above 1st Potsdam 1337 feet</i>	<i>1st Potsdam and limestone 1337 feet- 1765 feet</i>	<i>Below Casing 1765 feet- 2046 feet</i>
Calcium carbonate.....	21.23	21.46	13.42
Calcium sulphate.....	3.74	1.11	
Magnesium carbonate.....			4.80
Magnesium sulphate.....	15.11	15.12	2.10
Iron carbonate.....		0.27	0.12
Undetermined.....	0.55	2.21	0.99
Incrustating solids.....	40.63	40.17	21.43
Sodium sulphate.....	2.69	5.45	8.85
Sodium chloride.....	0.29	0.77	24.06
Sodium nitrate.....		0.04	
Non-incrustating solids.....	2.98	6.26	32.91
Total.....	43.61	46.43	54.34

This well is rather unique in that in placing the casings the one through the drift is made big enough to allow small suction pipes to be dropped between it and the inner casing thus making the water from either the upper or lower strata available. The available supply from the lower strata for a draw down of 150 feet was about 110 gallons per minute.

A study of these three wells bears out to a large degree the assumption that the Potsdam sandstone will give a more satisfactory water than the St. Peter sandstone. It also is evident that all parts of the same stratum cannot be relied upon to give exactly the same quality; this is shown by a comparison of the water from the first Potsdam of the Milwaukee well which shows 7.82 grains per gallon of incrustating solids, while the same stratum in the Northwestern was reported as bad and the Western Springs well showed 40.17 grains per gallon.

It further appears that increasing the depth beyond a certain point will probably increase the hardness without any great return in quantity of water, and that the capacity is limited to approximately 170 gallons per minute, according to the tests on these wells. In the territory around Chicago at least, a limit to the depth is fixed by the increased amount of salt in the lower levels.

More data are needed to establish the conclusions as drawn from these limited cases, and should cover the territory more completely. If, with the increased data, it is found that the above conclusions are generally borne out, it opens up an improved supply for small towns and industrial establishments that may be well worth the extra cost to obtain.

THE WATER SUPPLY OF LONGVIEW, TEXAS¹

BY P. E. GREEN

This paper is a description of the installation of a new water supply for the city of Longview, Texas. It is not a detailed technical description of this work, though more or less technical data are given, but more emphasis has been laid on the human interest end of the problem because it is believed it is typical of many small towns in the United States, and because it illustrates so accurately the workings of human nature in our average city officials.

The city of Longview, Texas, is a community of about 7000 inhabitants. Up to within the last five or six years it has had practically no public improvements, except an antiquated water works system.

A few years ago a sanitary sewer system was installed under a franchise. Some four years ago this system was purchased by the city, and it is now operated by it, charges being made in a manner similar to that for ordinary water connections. There is a so-called disposal plant consisting of a small sedimentation tank and about 1600 square feet of broken brick filled beds for a filter. Incidentally it may be noted that the city makes a net profit of about 20 per cent per annum on the sewer system.

The existing water supply, before the installation of the one to be described in this paper, consisted of two deep wells, one of them 1200 feet and the other 600 feet in depth. From them the water was pumped by means of an ordinary air lift into two reservoirs, and from the reservoirs the water was pumped by means of two duplex steam pumps of 1,000,000 gallons capacity each, into a stand-pipe, having a capacity of about 75,000 gallons. The water from the wells is of a peculiar character. It is clear, sparkling, and of exceedingly pleasant appearance. It has, however, a very high chlorine salt content which makes it unsuitable for general commercial and domestic use. A typical analysis of this well is shown:

¹ Read at meeting of Illinois Section, American Water Works Association, March 10, 1915.

	<i>Parts per million</i>
Suspended matter.....	None
Oxygen consumed.....	2.8
Organic nitrogen.....	0.33
Albuminoid of ammonia.....	0.08
Free ammonia.....	2.23
Nitrites.....	0.12
Nitrates.....	0.10
Chlorine.....	1160.00
Alkalinity.....	368.00

From the above it will be seen that the chlorine ran to 1160 p.p.m. Other analyses have shown as high as 1600 p.p.m. The alkalinity is also high, amounting to 368 p.p.m.

The water is decidedly salty in taste, though after using it for a time many people declared that they did not longer notice the taste of salt. On a stranger, its effect was frequently quite laxative, and lawns, etc., were soon ruined if it was used for sprinkling. However, in addition to its character, the supply was very limited, and while, when the wells were first installed as much as 300,000 gallons per day was obtained, this yield steadily dropped and ultimately it was difficult to get more than 100,000 gallons per day out of both wells. About 2000 people are served by the water and sewer system.

In 1911 and 1912 several disastrous fires occurred, during which there was practically no water available, and the mayor and city council, as well as the people generally, appreciated the fact that a new water supply was absolutely necessary. The writer was therefore commissioned to make an investigation of the subject.

There were three sources of supply to be considered: 1st, an artificial lake, known as Lake Lemont, about a mile west of the city; 2d, a small stream called Grace's Creek, running through the city; and 3d, the Sabine River, distant about three miles and a half from the city. Lake Lemont has a drainage area of about seven square miles. The Lake is about a mile long and from a quarter to one-half of a mile in width, and averages about five feet in depth. This lake is used for fishing and hunting purposes only. The investigation showed that its shallowness and limited water shed, together with the long continued dry spells which are characteristic of that part of the country, make it unsuitable as a source of supply.

The investigation of the second project, Grace's Creek, as it was called, developed that there was no available site for a dam, although

the water shed is approximately 25 square miles in area above the town.

This left the river as the only available source. The Sabine River above Longview has a water shed area of about 2900 square miles. The population on the water shed was about 136,000, almost entirely rural. From the very limited government data on the subject it was determined that the minimum flow would be about thirty cubic feet per second. The rainfall averaged about forty inches, and the run off from 10 per cent to 30 per cent. At times several months passed with no rain whatever.

Analyses were made of the Sabine River water, the water of Lake Lemont and of Grace's Creek, of which typical examples are included herewith:

LOCALITY	SABINE RIVER			GRACE'S CREEK	LAKE LEMONT	
	1912					
Date of collection	Feb. 13	Feb. 16	Feb. 28	Feb. 16	Feb. 13	Feb. 28
Date of analysis..	Feb. 16	Feb. 19	March 1	Feb. 19	Feb. 15	March 1
Physical analysis:						
Turbidity.....	60	75	120	40	60	50
Color.....	75	70	85	70	60	75
Odor.....	None	None	None	None	None	None
Sediment.....	Slight	.....	Slight	.....	Very slight	None
Chemical analysis:						
Suspended matter						
Total.....	23.000	21.00	39.000	7.00	16.000	16.000
Volatile... .	5.000	9.00	5.000	6.00	3.000	8.000
Fixed.....	18.000	12.00	34.000	1.00	13.000	8.000
Oxygen consumed	5.300	5.10	6.700	6.00	3.800	5.200
Nitrogen as:						
Organic nitrogen.....	0.340	0.24	0.360	0.17	0.410	0.520
Albuminoid ammonia.....	0.120	0.13	0.180	0.14	0.170	0.240
Free ammonia..	0.004	0.12	0.016	0.12	0.120	0.088
Nitrites.....	0.000	0.00	0.000	0.00	0.001	trace
Nitrates.....	0.020	0.00	0.020	0.00	0.060	0.060
Chlorine.....	16.000	16.00	18.000	13.00	6.000	7.000
Total hardness....	44.000	35.00	33.000	35.00	35.000	23.000
Alkalinity.....	20.000	22.00	20.000	18.00	22.000	22.000
Iron.....	1.000	1.00	1.000	1.00	trace	trace

Bacterial investigation showed that all the sources of supply were more or less contaminated, but none seriously. It was therefore recommended that a 1,000,000 gallon mechanical filter plant be built at the edge of the river, some three miles and a half from the city, and the water pumped from there to a new modern elevated tank.

The presentation of the report developed some very lively opposition to the river project. It was commonly stated that during the "black rise" the river was and always would be absolutely unsuitable for drinking purposes, that it would be salty, full of organic matter, etc., etc. This, in spite of the fact that very complete information had been obtained of the water shed, and nothing had developed which would indicate that at any time there would be any great difficulty in filtering the water, though it might be very hard sometimes. It also developed that there was a very strong sentiment in the city for the use of Lake Lemont, the first source of supply mentioned, as the location for the filtering plant. This was because it was so close to the city. However, the report was accepted, leaving the question of the source of supply to be later decided.

After the necessary bonds were voted there was a period of several months in which nothing was done. The bond market was bad, and no serious fires had occurred. As soon as the bonds had been voted the mayor and city council were deluged with letters and visits from promoters of various devices for purifying water, each sure that his device was the only one to secure the result desired, and all of them willing to absorb the cost of engineering in their price, so that the city would not be put to that unnecessary expense. Some of them were backed by very strong local sentiment through business connections, relatives, etc.

After three or four months of this kind of promotion the council was considerably bewildered. They very naturally desired to get the best plant at the least cost. Finally, as a sort of a compromise and with a shadowy idea that possibly there might be oil, since everyone was talking oil in this part of the world, it was decided to sink another well near the site of the old wells. Accordingly, a deep well drilling apparatus and a quantity of iron casing were purchased and a start made on drilling a well. This was soon abandoned and the outfit was later sold to a well drilling company.

About this time there was a small outbreak of typhoid fever in

the city which alarmed the mayor and council. They promptly sent samples of the well water to Chicago and to Dallas for analysis, and these analyses developed the fact that the water was suspicious, *B. coli* being found by both analyses. It was decided, however, that the cause of the contaminated water was in the condition surrounding the wells, and this condition was promptly remedied, and as promptly it was decided to go ahead with the Sabine River project.

Plans and specifications were then prepared, providing for a mechanical filtration plant of 1,000,000 gallons capacity, having two filter beds, a sedimentation basin of 500,000 gallons capacity, and a coagulation basin of 100,000 gallons capacity. Besides the filter plant proper there was included in the scheme a tunnel intake, two low-lift centrifugal pumps of 700 g.p.m. capacity, driven by 2300-volt, 60-cycle, 3-phase motors. Two high-lift pumps were provided, one, a 750-gallon 3-stage centrifugal, motor driven, and one 650-gallon, motor driven triplex. In addition a steam duplex pump was provided, for emergency high-lift pumping, and a small generator set to drive the low-lift pumps and light the plant in case of failure of the current. The current, furnished by a local company, was taken off at 2300 volts and stepped down for lighting. Alternative proposals were also invited on the filter plant, plans to be submitted by bidders.

Proposals for bids were advertised for and received. Since alternative proposals were possible the field of bids was quite broad. In general the alternatives proposed by the best of the filter companies provided a lesser time of sedimentation than the engineer's plans.

In several small cities in that part of Texas the crude scheme of settling surface water by means of dosing it with alum and allowing it to settle in small shallow circular basins had developed. The dosing apparatus of such a plant had been patented and the patentee, or his successors, had formed a company and sold the device to some active business man of a nearby city. This company, after the bonds were voted, became very urgent in an endeavor to secure the installation of their device, and submitted a bid. This was the only departure from standard practice proposed. It may be said that it was simply an adaptation of the St. Louis system on a small scale, without either the expert supervision or facilities for sedimentation possessed by the city of St. Louis.

The plans for a filtration plant, providing for six hours sedimentation, were finally accepted at a cost of about \$5000 under that of the engineer's plans, it seeming to be the unanimous opinion of the able engineers representing the various filter companies that the saving was justified.

The work has now been constructed and is just starting operation, though not fully tuned up yet. The city of Longview, after some three years of strenuous discussion, has now a first-class water supply. The total cost of the intake, filtration plant, three and one-half miles of 12-inch force main, a new 150,000 gallon elliptical bottom elevated tank, pumping machinery, motors, and auxiliary steam pumping plant, is about \$150,000, not including engineering.

As yet not much trouble has been experienced in handling the water, though at the time of this writing, February 3, the water is exceedingly turbid, and the alkalinity is very low. After 24 hours plain sedimentation there is no apparent reduction of turbidity. The beds are washed by taking water from the force main, in which the pressure is about 125 pounds. This is a mistake. A wash water tower should have been provided, since the ordinary pumpage, 650 gallons, is not enough to wash. Therefore no checks could be used between the wash water take off and the stand pipe. At the end of the first week of operation, the too sudden opening of the wash water valve caused a surge which sheared off several of the laterals and cracked the header. Gauge readings showed that the force main is subject to a pressure ranging from 60 to 160 pounds as the pumps are stopped or started. To remedy this a relief valve and automatic air valves have been installed.

The usual troubles with air pockets, best places for dosing, etc., have been encountered. It has been found for instance that applying the alum at the low lift pumps produces the best results for very turbid water. The best bacterial results have been obtained when the hypo is added about ten minutes before the filter beds.

Mr. H. N. Roberts, C.E., was the resident engineer in charge of the work and is now city engineer in charge of the operation of the plant.

COOLED DRINKING WATER¹

By R. F. MASSA

The existence of intimate relations between a proper drinking water supply and health is accepted, in a way, by all intelligent people. It is unfortunately true, however, that sanitary, like moral principles, are much more readily accepted as abstract truths than made a part of daily practice.

It is the writer's purpose in what follows to state the principles involved in supplying proper drinking water, and to describe the requirements of such a supply. It is his further purpose to make clear the importance of honoring these principles in the observance rather than in the breach. The material offered for consideration will be presented from the point of view, principally, of the factory manager, but the considerations which govern are essentially those touching the human rather than the purely mechanical element in manufacture, and they therefore have an essentially broad appeal and interest.

Suggestions have been taken from a number of articles that have appeared from time to time on this and allied subjects, as well as from experience, and the passage of time since these articles were consulted has so dimmed memory of the exact origin of many of the points that proper credit will be difficult if not impossible—

“An’ what ’e thought ’e might require,
’E went an’ took—the same as me!”

There are two essentially fundamental requirements in an efficient drinking water system. In working out such a supply, these two points govern: first, the water must be pure; second, it must be at a proper temperature.

The importance of purity of the supply has been recognized and has been generally insured. Various devices, operated by electricity and by steam, are provided and successfully operated for insuring a proper degree of purity. The final and equally vital problem has been much less successfully met. No matter how pure the water

¹ Read at meeting of Illinois Section, American Water Works Association, March 10, 1915.

may be, if its temperature is not right it will not serve its purpose. It will not be drunk. Further, no matter how pure the water supply may be, if it does not reach the user through means insuring that it has remained pure, a doubt is cast upon its purity amounting, in many cases, to practical certainty that it has been contaminated.

CORRECT TEMPERATURE FOR DRINKING WATER

The range of temperature at which water is palatable is rather narrow. Extensive experience has proven that there should not be a variation of over 5° as a maximum, from 50°. And yet, if one will apply a thermometer to the water supplied by ten drinking water fountains, it will be found in nine of the cases that the temperature is very far from this range.

There is a physiological basis for this preference for water at a temperature close to 50°. According to Dr. Thomas Darlington, secretary of the welfare committee of the American Iron and Steel Institute, water at this temperature stimulates the heart and also has some influence in relieving the internal temperature and equalizing it throughout the body.

ILLNESS FROM LOWER TEMPERATURES

On the other hand, water at a temperature appreciably lower than that named frequently produces cramps, or, if taken in quantities insufficient to produce this trouble in a clearly defined form, it lowers the efficiency of the individual affected, while leaving him in service. There is at the same time a further loss of efficiency in too little water having been consumed, and the whole value of the supply has therefore been destroyed. Water that is too cold is avoided as instinctively as water that is too warm. Tests to determine the influence of temperature upon the quantity consumed indicate a falling off of one-third with a fall in temperature from 50° F. to 40°.

STATEMENT OF SANITARY PROBLEMS INVOLVED IN PRODUCING A PERFECT SYSTEM

Having provided for the purity of the supply, the next question is how to get the water from the point where its purity is assured to the point at which it is to be consumed, with certainty that its purity has not been diminished, and further to deliver it at the palatable temperature.

Troubles from ice

One of the first difficulties encountered has been the problem of cooling. Water otherwise perfectly satisfactory for drinking has been contaminated by adding dirty ice or keeping it in a water cooler that has not received proper attention. This difficulty has in many cases, although unfortunately not in all, led to the use of receptacles in which the water is placed near the ice, or is in some way kept out of actual contact with it. Even though the ice is pure, it is generally handled in ways that are not conducive to cleanliness. Obviously, such ice should not come in contact with the water to be cooled, even aside from the question of temperature.

Futility of bottled waters

The second difficulty now develops: the problem of distribution. The purchase of waters for drinking has greatly increased during recent years, owing to the belief that by purchasing water in bottles or jugs there would be greater certainty of obtaining something that is entirely satisfactory. Some years ago, however, the Connecticut State Agricultural Experiment Station examined a considerable number of samples of such waters, and not only found a number that were not above suspicion, but pointed out that waters from uncontaminated sources might readily become unwholesome if carelessly marketed or bottled in unclean receptacles. The problem of proper cleansing of receptacles is by no means a simple matter.

The Bureau of Chemistry of the Agricultural Department at Washington has also reported an extended series of investigations which show that in many cases when the waters reach the consumer the bottles may not contain the water indicated by the labels, owing to incorrect labelling in the first place, or to tampering with the contents of the bottle on the way.

Even though the purity of the supply and the cleanliness of the method of handling the water are unquestioned, the use of drinking cups at the fountains invariably involves their use more or less in common, no matter what effort there may be toward the requirement of individual cups.

SANITARY SPECIFICATIONS FOR AN IDEAL SYSTEM

The ideal method of supplying drinking water whether in a public building, an apartment house, a hotel, a school or a factory, must aim,

First. At encouraging the use of a sufficient quantity by each person.

Second. The water must be made attractive.

Third. It must be carried from the point at which its purity is assured to the lips of the consumer in such a way as to insure its continuing pure.

Fourth. The drinking fountain should be white and clean in appearance.

Fifth. The water itself should be clear and sparkling.

Sixth. It should be placed convenient to the worker.

Seventh. Its temperature should be regulated and held constantly as close as possible to 50° F.

Quantity of water required per person

The quantity of water consumed by the average person amounts to about 3½ pints per day. Hot weather and exercise increase the demand.

The amount of water that must be supplied for each person in a drinking water system will vary through very wide limits, depending upon the design of the fountain. Usually where the design has been properly worked out the amount runs from one to two gallons per person per day. The larger figure is taken from the results in a large steel works. In schools the figure will often run as low as one-half gallon per person.

Results running up as high as 6 gallons per man and higher are occasionally encountered, but such figures seem invariably to go with defective fountain design or a water supply at a temperature above a palatable degree. Where the fountain is badly designed, there is often excessive waste because so small a portion of the water flowing can be drunk. Where the temperature of the supply is higher than it should be, the man will let the water run, to get it as cold as possible, and will otherwise waste it.

Economy of properly designed bubblers

Contrary to what one would expect, the consumption of water with a properly designed fountain is actually less per person than with drinking cups, where the temperature of the water and its attractiveness in other respects are the same. Tests made by Inspector Dougherty of the Water Department, Washington, D. C., showed definite economy by making the change from cups to bubblers. The reason for this is undoubtedly the effort to cleanse the public cup before it is used and the almost invariable drawing of a larger quantity of water than is consumed.

The design of bubbler fountains

It is obvious that in the design of the drinking fountains, the greatest care should be taken to produce the most efficient possible fountain jet, since the consumption of water varies through the widest limits, as above indicated, according to the efficiency or inefficiency of the jet.

Many of the older designs of fountains seem to have attempted to duplicate natural springs. Even when these fountains are fitted with self-closing valves so that no water flows except when the fountain is being used, only a very small percentage of the water that flows can be consumed. A design very much to be preferred as a matter of economy and of sanitary value is therefore that in which the water issues in the form of a jet. In fountains of this design, where the stream is allowed to rise to a point high enough so that there is no danger of the lips coming in contact with the fountain, the larger part of the water that flows can be drunk. A further advantage of the stronger stream is that it will flush off quickly any dirt that may have been carelessly or maliciously allowed to accumulate at the orifice. In some fountain designs, even this possibility is overcome by arranging a series of very small jets directed obliquely upward toward a common point at which the various jets impinge upon each other and the resultant stream is directed vertically. With this design, and, in fact, with any design, economy is sometimes attempted by cutting down the size of the stream in order to reduce the waste during the moment the man is drinking. This economy is readily carried to a point where it does more harm than good, because too small a stream will

not only waste a slight amount of time, but is very unsatisfactory to drink from.

It should not be necessary to point out the importance of having the shortest possible connections between the circulating system and the fountain so as to reduce the amount of water that may stand in the pipe and become warm. If this quantity of water is appreciable, the employees quickly get the habit of holding the fountain open long enough to insure that the "dead" pipe has emptied itself. Naturally, this means considerable waste of water and of cooling effect.

The importance of being able to keep the fountain and its surroundings thoroughly clean is also too obvious to call for special comment, and of course the design of the fountain as regards strength and appearance is a matter largely of its location, except that no matter how it is placed the appearance of cleanliness is vital.

CONSIDERATIONS OF COST AND OF VALUE

Cost of mechanical cooling versus ice

In the narrowest sense, the economy of a mechanically cooled drinking water system compared to the same system ice cooled, will also invariably work out in favor of the mechanical method, assuming that the equipment is at all suited to this method. But such a comparison is of little value, since the system of distributing the water is almost invariably changed at the same time that the method of cooling is altered, and there are too many factors to permit any one answer to cover all cases. In the New York office of one large company, the cost for this service was cut, by installing a machine and a better system of distribution, to about 25 per cent of the former cost. At the same time, the service was very much more satisfactory to the office force.

It cannot be too strongly emphasized, however, that considering economy and cost of operation where it involves mechanical cooling, or cost of ice, is merely considering the one least important item in the account and one that may well be sacrificed to other more important considerations.

Influence of improved conditions on employees

In the case of industrial plants, one large element involved in arranging a good system of supply is the effect on the employees'

feelings. Consideration for the comfort and well-being of the employees has a direct effect on their attitude to the plant. While in general, the character of the labor force determines to a certain extent the conditions in the place of work, while stenographers, to take an example, will not put up with the same lavatory facilities as factory girls, it is equally true that the conditions in the factory have a controlling effect on the character of the help that will seek employment.

Influence of proper equipment on efficiency

It is not often possible to get an accurate estimate of the improved efficiency following the installation of proper drinking water equipment, since the organization of the work in many shops is too elastic to bring out clearly the full effect. That effect is present, however, no matter how completely it may be hidden. In a rolling mill, one roller working at less than full efficiency lowers the capacity of the entire mill. Tonnage once lost is lost permanently.

In fact, in any industry where the work is arranged in a sequence of operations the effect of any falling off in the efficiency of the individual shows itself immediately. This prompt discovery of inefficiency, indeed, is one of the advantages of such an arrangement.

This arrangement of the work in a close sequence requires the holding of extra men ready to throw in at points needing reinforcement. This need of reinforcement appears very quickly where the operations follow each other closely, as, for instance, when the work moves along on a conveyor. This condition may be observed in the large packing houses. It may also be observed on the assembling floor of one of the large automobile companies. And in such work as this, the amount of extra work required is dependent on the general physical condition of the men, and is a measure of their condition.

As stated above, the difference between factories in which the organization brings out these defects in efficiency and those in which it does not bring them out, lies simply in the fact that in one case the defects are seen and in the other case they exist unseen.

The labor element in cost of production

In American factories, the labor cost is the big item. When one analyzes the prestige of American machinery, it will be found

to be due to the designs, to the tools and methods—in other words, to American engineering and also the higher grade of labor which is attracted by the better pay.

Within the shop the greatest pains are taken with the equipment. Steam engineers are provided to take care of the steam power, a building and repair department is provided for the factory and its general equipment, and a mechanical engineer and electrical engineer supervise the machines, machine tools and the electrical equipment. The one item, however, which is most expensive of all receives too little attention. The human mechanism, which after all is the most complicated mechanism in the organization, the most sensitive and by far the most responsive to proper treatment and proper conditions, is allowed to work under conditions which are given only the most casual care.

In the case of one of the larger companies that have investigated this matter thoroughly, there has been found a marked decrease in the number of absences in the summer time due to cramps, summer complaint, etc., since a properly designed system was installed, and at the present time practically all the cases of absences from work during the summer originate in one small and isolated section of the factory which it was not practical to provide with properly cooled water and which is still served by means of ice.

In a large rolling mill in the Pittsburgh district, there were formerly from two to five men overcome on practically every hot summer day before a modern system of cooling the water supply was installed. Since that time, this number of cases of heat prostration will be the toll of an entire season, and in the case of one recent season, one day, July 5, accounted for every case that occurred that year.

CONSIDERATIONS GOVERNING THE LAYOUT OF A COOLING SYSTEM

Cleanliness

The importance of absolute cleanliness in drinking water systems cannot be too strongly or too frequently emphasized. All surfaces with which the water comes in contact should be smooth and accessible for keeping clean without any particular effort, because the help usually available for such service is not of a type that will give any great amount of conscience to the work. Obstructions such as

pipe coils and supports should be designed with this in view. Proper facilities for flushing the tank should be provided to further assist in keeping things clean.

In many designs of cooling system, it is impossible to prevent the formation of ice and the consequent deposit of salts that are present in all natural waters and that are frozen out of solution as the ice is formed. The accumulation of these deposits and of organic matter that generally is present and that is also frozen out of solution, makes proper flushing especially important. Although such matter as may be present is presumably harmless in normal quantities, it is possible that in some cases it may prove dangerous in the increased quantity which its segregation by freezing brings about. And even though this material may be harmless in a given case, its appearance does not tend toward making the water attractive. The greatest care should therefore be taken in designing a system to avoid the formation of ice, so far as it is possible to do so. This is a matter generally left, of necessity, to the refrigerating engineer.

There are a number of arrangements in common use for cooling the water. In one system, the water is distributed uniformly along the top of a bank of coils containing the refrigerating medium and is allowed to trickle down over these coils and to collect in a tank below from which it is pumped to the distributing system. This arrangement has the advantage of comparatively ready access for cleaning, without the waste of any great amount of refrigerated water. Another arrangement frequently used is the immersion of refrigerating coils in a tank of the water. This arrangement is less desirable than that above mentioned, because of the probability of ice forming on parts of the coils. The circulation of the water over the cooling surfaces is likely to be sluggish in spots, and in fact, is practically certain to be, so that the ice will almost invariably form to a greater or lesser extent.

A third system that is in more or less use, is the one in which a drum or series of disks containing the refrigerant is revolved in the water to be cooled.

In all of these systems, there is more or less danger of contamination of the water by impurities getting in through ill-fitting covers, unless this matter is given proper consideration.

Reducing heat losses

The limitation upon the area that may be served economically from a single refrigerating unit has not been generally recognized because of the relative newness of the subject. It has been found in general, however, that the length and diameter of water distributing mains insulated with the best pipe covering known, should not exceed about 2000 feet of 1½-inch pipe as a maximum, whether the main is arranged in a loop returning the water to the original point, to be re-cooled, or carries it to a second cooling station. This limitation is due to the heat losses into the pipe through the insulation, and power necessary to pump the water through the system fast enough to avoid too great a rise of temperature. Where longer mains are used, a result of failure to analyze the losses properly is that the temperature of the water will have to be too low to be used with safety at certain points, if its temperature is to continue low enough at the end of the loop to be palatable. The installation of such a system simply means that the expense of making it has been incurred and the real purpose of the work has been lost sight of.

In a recent installation in a large factory in central Ohio, the matter of length of mains was ignored, and the result was that the boiler and engine room force whose drinking fountains were supplied by water immediately after it had left the refrigerating machine, was compelled to drink water at so low a temperature—namely under 40°, that there was constant difficulty throughout the season from summer complaints of one kind and another.

It is, of course, impossible to draw the line between requirements calling for one and those calling for more than one machine without a study of local conditions, but, as the length of the circuit increases, the size of the mains to permit pumping the necessary quantity of water to avoid too great a range of temperature in the circuit increases rapidly, if the water is to be pumped without forcing the friction up above a proper limit, and with this increase the heat losses become excessive, while at the same time the cost of the installation is rapidly increased. In many cases the decreased cost of piping, due to the possibility of using smaller diameters of pipe and shorter circuits through which heat may enter the system, becomes a decisive factor in favor of installing more than one machine. Naturally, however, this matter is not of importance except in very large plants.

In laying out a drinking water system, there are obviously a number of factors which cannot be determined with any great degree of accuracy. It is important, therefore, that the capacity of the refrigerating unit shall be amply large to allow for the inevitable factor of ignorance in the laying out of the system and the further question as to whether it can be given skilled attention or not and whether this attention can be given frequently or only at considerable intervals, because in the latter case the capacity of the plant must necessarily be run at a lower point than where attention is more regular and more frequent.

A further matter calling for attention is that means must be provided to meet the requirements instantly when the period of heavy load comes on at the noon hour.

Further, the use of small units scattered at various points convenient to the more or less separated groups requiring fountains gives the system a flexibility as regards extensions that cannot be secured with the single central distributing plant. As additional buildings are constructed, the drinking water system corresponding may be added without interference with the existing system, whereas in a central system the mains are very likely to have been laid out of such size as not to permit their handling the large amount of water required without causing excessive friction.

Location of fountains

In laying out a system the approximate location of the fountains is, of course, determined by the requirements of the work. The number of fountains in a given location is determined by the number of people to be served. In general one fountain for every 100 persons to be served may be taken as a fair average, although the character of the work will affect this number, increasing or decreasing it as the case may be. In any case, the upper limit should be one fountain for every 200 persons.

If the fountains are placed too far apart, there is of course a loss of time going back and forth. No definite distance can be assigned. The distance must invariably depend upon local conditions.

One precaution is desirable in locating fountains; namely, to be sure that two fountains on different parts of the distributing system are not placed near together. Where there is even a very small

difference in the temperature of the water supplied, the people will always go to the cooler water even though the distance is considerably greater.

Insulation

The matter of proper insulation of drinking water piping is perhaps the most important item in arranging the piping system, except the design of the mains so that they may be short as possible.

Owing to the difficulty of placing the pipes in the ground in many cases and to the uncertainty regarding the dryness of the insulation where it is so placed, and therefore of its insulating value, the piping system is more often placed above the ground in passing from building to building. In any case, the heat losses through the insulation are generally the largest item to be taken care of by the refrigerating machine and too great emphasis, therefore, cannot be laid upon the importance of using the very best insulation possible.

There is a great mixture of motives that are effective at the present time in improving factory conditions. To the mind of one person, it is a matter of charity; to another, it is philanthropy and 5 per cent; to a third it is a question of what the law requires, and the law is requiring more and more all the time; to a fourth it is a realization that the prosperity and comfort of one man is bound up with the prosperity and comfort of every other—that we are dependent upon one another, and that, in a sense every man is his brother's keeper, even from the most selfish motive. However, whatever motive makes its appeal in any individual case, the fact remains that improved factory conditions are gradually coming more and more into consideration, and that conditions will continue to improve as a more intelligent understanding of their effect becomes general.

TREATMENT OF WATER FOR LOCOMOTIVE USE¹

BY W. A. POWNALL²

Most of the railroads in the central part of this country use some kind of water treatment to reduce boiler troubles resulting from use of water more or less high in incrusting matter. Some roads are pretty well equipped with softeners, which by use of lime and soda ash remove practically all of the incrusting solids; some roads have these softeners for their worst waters only, some use proprietary anti-scaling compounds, and others use soda ash alone as a means of preventing scale formation in their boilers. It is the purpose of this paper to deal with the last-named and to outline the methods of applying the soda ash treatment, its advantages and disadvantages and the results obtainable.

Water as it is pumped contains two classes of mineral salts the amounts of which determine its fitness or unfitness for locomotive use, the incrusting salts and the alkali salts. The incrusting salts or "total hardness" may be divided into the carbonate hardness, mostly carbonates of lime and magnesia, and the "sulphate hardness" mostly sulphates of lime and magnesia. When water is boiled at atmospheric pressure or higher the carbonates precipitate, either as soft mud or a bulky scale on the heating surfaces. The sulphate hardness remains in solution up to 60 pounds pressure, but above that it crystallizes as a very hard porcelain-like scale on the heating surface. Metal surfaces thus insulated by this scale become much overheated, resulting in leaky flues, staybolts and shortened life of firebox sheets.

The alkali salts are usually the sulphate, carbonate and chloride of sodium. These remain in solution, increasing in amount as more water is boiled away, until such a concentration is reached that the water begins to "foam." Waters high in alkali salts are, on account of their tendency to cause foaming, undesirable for boiler use. It is usually possible in Illinois to find water low in alkali

¹ Read at meeting of Illinois Section, American Water Works Association, March 10, 1915.

² Water Engineer Wabash Railroad, Decatur, Illinois.

salts so the foaming trouble seldom bothers until the hard waters are made mildly alkali by treating them with soda ash. Farther west railroads often have to use waters high in alkali salts which cause acute foaming trouble, although this trouble is lessened by special treatment. In addition to these mineral salts surface waters at times carry considerable suspended matter, and decayed animal and vegetable matter, which aggravate the foaming tendency.

CAUSES OF BOILER TROUBLES

The primary cause of leaky flues, fireboxes and staybolts is unequal expansion and contraction brought about by overheating of the metal, due to it being insulated from the water by a layer of scale. These troubles will be accentuated by any sudden cooling of the metal such as might be caused by holes in the fire, working engine very hard and then suddenly shutting off steam and leaving shut off for some time, cold water from injector falling to bottom of boiler, and to washing boilers with cold water.

The average operating official does not concern himself with the condition of boilers as long as the engines are going over the road in good time without failing. The flues may have considerable scale on them and with careful boiler work get along in the summer without much leaking trouble, but cold weather soon starts an epidemic of engine failures on account of leaking boiler, and it is then that the need of water treatment makes itself felt. The chemist usually starts first after the district that is showing the most leaking failures, for a leaking failure means delay to traffic, and sending out another engine and crew to pull in the train and failed engine. This costs considerable money besides requiring additional engines where such failures are frequent.

TREATMENT

The prevention of scale formation may be accomplished by using water softeners which remove practically all of the hardness and suspended solids, or by treating each water with enough soda ash to neutralize the sulphate hardness, and provide a slight excess of soda ash, all of the scale forming solids being converted into a soft sludge which can be readily blown out through a properly located blow-off cock. Soda ash or sodium carbonate is found in some waters, and unless it is so high as to cause foaming trouble, waters of this type are desirable for boiler purposes in that they will not

form scale and require no treatment; but unfortunately most waters contain sulphate hardness and must be treated.

The soda ash is changed to sodium sulphate in the boiler, and locomotive boilers worked to full capacity and using surface waters will usually be in a foaming condition when this sodium sulphate and other sodium salts, in water from the boiler are over 2000 parts per million. Where only clear well waters are used this limit will be 2500 or even higher, and in stationary boilers, with their lower rate of evaporation and greater steam space, the foaming point may be 5000 to 6000 parts per million. The mud and carbonates precipitated in the boiler, if allowed to accumulate, may cause trouble in three ways:

1. The foaming tendency of the water in the boiler increases.
2. Heavier scale will form at times when treatment is light.
3. There is danger from mud-burning.

It is essential, therefore, that engines using soda ash treated water be equipped with suitable blow-off arrangement for removing the sludge from the boiler. Critical examinations of the deposits in boilers have shown that, where there is scale formation, the heavier pieces of scale drop out in the barrel and front of the side legs, while the lighter scales and mud are carried further back by the circulation of the water and deposited in the back of the side legs and in back water leg. With properly treated water there is no scale formation, and the sludge can best be removed by means of a perforated pipe extending across and lying on the back mud ring and connected to a blow-off cock located at back corner. The primary purpose of this blow-off cock is to keep the alkali salts in the boiler below the foaming point. Incidentally the sludge is removed, and where treatment is maintained full and continuous, engines can be run indefinitely without having to wash out boiler. The federal law requires boilers to be washed at least every 30 days, but where waters are high in incrusting matter a deficiency of treatment will result in rapid scale formation, and on such districts it is wise to wash boilers every two weeks rather than risk scale banks and burned sheets, if, by lack of supervision, neglect or other cause, treatment had become light. One passenger engine ran 10,000 miles without washout or change of water on an Illinois division using waters of average hardness of 280 parts per million and treated with one-half pound soda ash per 1000 gallons, yet at the end of the test the boiler showed no scale formation and only a small amount of soft sludge in side water legs.

AMOUNT OF BLOWING OUT NECESSARY

A pound of soda ash forms 1.34 pounds of sodium sulphate, and calculations show that when 12.42 pounds of soda ash have been used per 1000 gallons of water in the boiler, the sodium sulphate will amount to 2000 parts per million, and to prevent foaming water must be changed completely or enough blown out to keep concentration below 2000. A treatment of 1 pound soda ash per 1000 gallons necessitates blowing out $\frac{1}{12.42}$ or 8.05 per cent of the water used, $\frac{1}{2}$ pound per 1000 gallons, 4 per cent, etc. In stationary practice, where higher concentration can be carried, the amount of blowing off is much less.

This waste at the blow-off cock is the expensive item against water treatment. A pound of soda ash entails a waste of 80.5 gallons of water that has been heated to the temperature of boiler pressure steam, and a locomotive boiler carrying 200 pounds of steam will use 30.5 pounds of Illinois coal to heat this water. At \$1.50 per ton this coal will cost 2.29 cents, the 80 gallons of water at 5 cents per 1000 gallons 0.4 cent, a total of 2.69 cents per pound of soda ash used. This will be less with lower steam pressures and where a higher concentration than 2000 can be carried, and there is of course no waste while bringing the water up to this foaming point.

Where treatment is heavy or waters contain considerable natural alkali, it becomes impractical to do the necessary blowing off, and it is cheaper and more satisfactory to change water in boiler frequently at terminals, or use some anti-foaming compound that allows a higher concentration of alkali salts before foaming occurs. Passenger engines should be washed out or have water changed often enough so that the terminal blowing off will keep the boiler from foaming without having to blow out en route.

The following procedure should be followed to overcome boiler troubles on any certain division.

First, get the best available water supply; second, provide suitable arrangements for blowing off engines and line up to have engines blown systematically at terminal and on road; third, treat all waters containing sulphate hardness with the necessary amount of soda ash, and fourth, provide sufficient chemical supervision, to maintain correct treatment at all times.

WATER SUPPLIES

Chemical analyses of the water in use for locomotives should be made, and where the sulphate hardness or the alkali salts are high, an effort should be made to locate a better supply that can be substituted at not prohibitive expense. In the past, railroads usually took the first water available, regardless of the quality, and there are many places where these old supplies, high in sulphate hardness, can easily be replaced by much softer water. The cost of treating the waters with the attendant cost of coal wasted as a result of this treatment should be considered in changing supplies, and it will usually be found that the better water will pay for itself in a short time.

BLOWING OFF BOILER

At roundhouses there should be a place for blowing off just before engine goes on to clinker pit, and hostlers should be instructed to blow out full glass of water from every incoming engine and should be held strictly to account for obeying these instructions. It is also a good plan to provide a similar arrangement on outgoing track to give enginemen opportunity to blow off before leaving. Enginemen are instructed through letters explaining the water treatment, blowing off, etc., and individually by their road foremen.

TREATMENT

Our methods of analysis may not appeal to the chemist, but we determine only the total dissolved solids, the total hardness by soap test, and the sulphate hardness by subtracting the alkalinity to methylorange from the total hardness. Every water containing sulphate hardness is treated with enough soda ash to neutralize this sulphate and provide excess, such that waters taken from boilers of engines using the treated water will show about 15 per cent of the total alkali salts as sodium carbonate. Probably only 5 per cent will keep the water in a non-incrusting condition unless the hardness is high, but the 15 per cent is carried as insurance against occasional neglect or deficiency of treatment at some stations.

The soda ash solution would best be used evenly according to the flow of water, and should go through a separate pipe line to the water tank so there will be a chance for chemical reaction before the

treated water passes into the pipe lines. The solution may be introduced by small steam pump, by plunger pump operated by main pump or water motor through which all the water passes; it may be forced continuously by air pressure, solution passing through a $\frac{3}{4}$ -inch diameter hole; by a by-pass arrangement in which part of the water is by-passed from the main and displaces the solution in proportion to the water flowing; and when no other method is available it may be placed direct in engine tanks.

SUPERVISION OF TREATMENT

A very important feature of treating waters with soda ash alone is to provide enough chemical inspection and supervision to insure keeping all waters treated fully and with as little interruption as possible. If the treatment is light on account of neglect of pumpers or insufficient soda ash called for in directions so that the treated waters in general still show some sulphate hardness, then the only benefit is in the small decrease in hardness of the water, due to some precipitation of the carbonates in the supply tub. The foaming tendency of the water will have increased in proportion to the amount of soda ash used, and boiler must be blown off nearly as much as with full treatment; but the hard scale still forms on the flues and causes the leaking troubles that the soda ash is expected to cure. To keep treatment right a road water inspector should make frequent analyses of the raw and treated waters for sulphate hardness or sodium carbonate, and should also inspect apparatus for treatment. If this inspection shows treatment wrong he should do what he can on the ground toward adjusting matters, and report to division officials when other steps are necessary to correct pumper or repair apparatus. On some divisions where the raw waters do not vary much in quality at different times of the year and where there is a dependable class of men handling the soda ash, it will not be necessary to provide so much chemical supervision after treatment has been started and is going satisfactorily, and one water inspector may be able to handle two or three such divisions. On other divisions where the waters vary considerably in quality, where the pumpers are changing frequently or where slight falling off in treatment is followed quickly by boilers leaking, it pays to keep a water inspector on the division all the time.

RESULTS OF TREATMENT

The advantages gained by full and systematic treatment of water are as follows:

1. Engine failures due to leaky boilers are reduced to a minimum. On divisions where soda ash treatment has been in use for several years the records show an average mileage per engine failure due to leaky flues of 513,000 miles. The total yearly mileage on these divisions is about 10,000,000, all waters are treated and most of the engines are heavy power with flues 19 and 21 feet long.

2. Much less boiler work is needed, mileage of flues between shopping is materially increased and the cost of boiler repairs is correspondingly decreased. It is not necessary to shop an engine for flues before the machinery needs it.

3. Mileage between washings of boiler is increased.

4. There is a saving of fuel due to having boiler free from scale. Also a saving of the fuel that heats the water lost from leaking boilers.

5. Engine is not held out of service so much for washing and working on boiler.

The disadvantages are the increased foaming tendency of the treated water and the waste of coal and water in blowing off to overcome this foaming tendency.

The cost of water treatment can be given fairly closely, but it is rather difficult to give in dollars and cents the various savings due to treatment. Some estimates of these costs and savings are given here as so much per engine per year based on a freight engine of about 50,000 pounds tractive force using waters treated with an average of one-half pound soda ash per 1000 gallons.

Saving per engine per year

Boiler repairs.....	\$250.00
Fuel 5 per cent of \$7200.....	360.00
Washing boiler.....	40.00
Ten days extra service at \$15 per day.....	150.00
	<u>\$800.00</u>

Cost per engine per year

Soda ash 3000 lbs. at 0.85 ct. per lb.....	\$25.50
Coal wasted 45.8 tons at \$1.50.....	68.70
Water wasted 240,000 gals. at \$.05 per 1000 gals.....	12.00
Supervision of treatment at 0.2 ct. per 1000 gals.....	12.00
	<u>\$118.20</u>
Net saving per engine per year.....	\$681.80

These figures are for a large engine under average water conditions. Where the waters are hard the saving in boiler repairs and fuel wasted on account of scaled boiler would be considerably higher. A number of years ago Professor Schmidt of the University of Illinois in tests on an Illinois Central engine reported a saving of 10 per cent in a clean boiler over the boiler with scale of average thickness $\frac{1}{16}$ inch. The percentage will run higher with heavier scale, and the assumption of a 5 per cent saving is conservative. The above net saving of \$681.80 multiplied by a number of engines runs into a large amount of money, and shows the financial advantages of water treatment for a railroad.

Before closing the writer would like to say a word about treatment with barium salts. The great objection to the use of soda ash is the increased foaming tendency of the treated water, and this bad feature keeps many railroads and power plants from using soda ash. Barium hydrate precipitates the sulphate hardness, an equal amount of carbonate hardness and does not increase the soluble salts or foaming tendency of the water. It is therefore rather ideal for water treatment, but thus far has not come into general use on account of its high price. Barium carbonate is being used in Germany for water softening, it is just as cheap as soda ash, and has not the foaming objection. Settling tanks are necessary with the barium treatment, involving a larger initial outlay than with soda ash. Development of processes for using barium carbonate or decreasing the cost of making barium hydrate would increase very much the amount of water softened for boiler purposes.

KINKS IN THE CONTROL OF HYPOCHLORITE AT DENVER¹

By W. W. DE BERARD

Hydraulic mixers of the type used in cyanide plants are employed to dissolve and mix bleach in the four installations which sterilize the water supplied by the Denver Union Water Company. Other novel details of these plants include the graduation of the scales on the solution tanks in pounds of solution and the control of the flow from the constant head box by special long-lever controlled plug cocks.

In the arrangement at Willard where there is a 10,000,000 gallon rapid filter plant, two horizontal solution tanks 12 feet long set 5-foot centers are made out of 48-inch woodstave pipe. Above one end of these tanks is a mixing tank consisting of a 50-gallon barrel with the necessary inlets, outlet pipes connecting the mixing barrel with the solution tanks, water supply and the drain. To agitate the chemical with the water in the mixer barrel, a 1-inch pipe entering at the bottom is reduced to a $\frac{1}{4}$ -inch nozzle which extends up into a 2-inch four-way cross. The side outlets of the cross are open. From the top outlet a 2-inch pipe extends above the top of the barrel and terminates in a tee into which are screwed nipples and turned down elbows. The discharge is thus given a downward motion. A branch carries part of the supply through the side of the barrel about 2 inches above the bottom. A 45-degree elbow with a $\frac{1}{4}$ -inch nozzle on the inner end of this pipe gives the solution a whirling motion which throws all of the sediment to the center.

In operation enough of the dry chemical is weighed out, to make up a one per cent solution, and dumped into the barrel, which is full of clear water. Filtered water under 75-pound head is then turned on. The jet action of the water entering the tee at the bottom of the barrel pulls water and undissolved chemical into the central pipe, or hydraulic elevator as it is called, and discharges it at the top. The swirling motion of the water entering at the side of the barrel rolls the undissolved chemical constantly toward the center

¹ Read at meeting of Illinois Section, American Water Works Association, March 10, 1915.



of chemical. Readings of the gauge are taken at one-hour intervals, and adjustment made if the necessary quantity is not feeding. By having the scale read in pounds a very simple calculation, as outlined in the *Engineering Record* of July 25, 1908, gives results in grains per gallon, sufficiently accurate for all practical purposes. Pounds used between readings divided by the product of the minutes between readings by the rate of flow of the treated water expressed in million gallons per day gives the grains per gallon applied within one per cent of the correct figure. Following the recent practice of expressing results in pounds per million gallons, the weir scales have been calculated to read in gallons per hour, so that one division gives results at once, the solution tank being read every hour.

Graduation of the scale is accomplished by actually weighing into it 200 pounds of water from a small barrel resting on a scale. Points are marked on the scale board after each addition. Graduations between these intervals are interpolated down to 10 pounds of water which with the one per cent solutions used means 0.1 pound of chemical. A 4 x 4-inch pine stick is grooved to admit the $\frac{1}{2}$ -inch glass gauge flush with the outside. The pound marks, about $\frac{1}{2}$ -inch apart in the center of the tank, extend across the face of the 4 x 4-inch stick, while the $\frac{1}{10}$ -pound marks are on a graduated strip at the back of the glass, an arrangement permitting easy reading.

To obviate the etching of the glass tube by the hypochlorite, clear water is run into the tube as soon as the storage tank is filled, or the gauge cock may be closed during the filling operation so as to exclude the hypochlorite solution at all times. The difference in the reading due to the difference in the specific gravities of the water and the solution is too small to correct.

CONSTANT HEAD CONTROL

Instead of the usual orifice box a simple arrangement used by the company for some time in the feeding of coagulant solution at the Willard plant has been used with slight modifications for the hypochlorite of lime feed. The former coagulant rig consists of a 30-inch vitrified sewer pipe set bell end down and filled in with about 10 inches of concrete to make a bottom. Reliance was placed on the coagulant to insure tightness, but the pipe never leaked. A hole was drilled through the pipe just above the bell for the entrance of a $\frac{3}{4}$ -inch brass pipe, which extended horizontally to an upturned ell

in the center of the vitrified pipe. A short piece of pipe was screwed into the ell long enough to rise a few inches above the concrete surface so as not to take in sediment. A constant head supply to this tank was furnished through an ordinary brass hopper ball cock. The outlet was through a plug cock with a lever handle extended by a wire pointer over a graduated board. The graduations were arbitrary as the cock was eaten out in time and gave increased discharges for the same setting. This was of little consequence so long as the cock did not leak, for reliance was placed entirely on reading the gauge on the solution tank for applying the correct amount of coagulant.

In the hypochlorite of lime plants the vitrified pipe was replaced by whiskey barrels. Ordinary ball cocks coated with paraffine or blocks of wood dipped in asphalt are used to keep a constant head and $\frac{3}{4}$ -inch steam cocks with extended lever handles control the discharge. A fine adjustment screw with the fulcrum and nut set in tapered holes in a fixed quadrant, and the lever respectively allow the operator to remove the screw, flush the valve and replace the lever at exactly the former position. The plug in the cock is filed away for $\frac{3}{8}$ -inch with a $\frac{1}{4}$ -inch rat tail file to give a fine stream.

Design and construction of these various devices were carried out under the direction of D. G. Thomas, chief engineer of the Denver Union Water Company.

THE NEW FILTRATION PLANT AT QUINCY, ILLINOIS¹

BY W. R. GELSTON

On the first day of September, 1914, one of the oldest mechanical filter plants in the United States was abandoned and a complete modern purification system was placed in operation at Quincy, Illinois, to take its place.

The old plant was built about the year 1891 under the O. H. Jewell patents and consisted of a stone masonry sedimentation basin 70 feet by 70 feet in area and 9 feet deep and 14 wooden tank filters 12 feet in diameter. There was also a small clear well under the filter tanks. This plant provided a sedimentation period of about one hour and the capacity of the filters was about 4,000,000 gallons per day under the usual rating for mechanical filters.

The new plant is of reinforced concrete with brick superstructure, steel doors and windows and it is absolutely fireproof. Three thousand yards of solid rock were excavated to prepare the site for the foundation and the entire plant rests upon solid rock. The east wall is also backed up by a solid limestone ledge which rises from 12 to 15 feet above the basin floors.

The concrete structure is 172 feet by 89 feet and the highest concrete walls rise 25 feet above the footings. Of the total area, the six 1,000,000 gallon filter units, with the pipe gallery, cover 40 feet by 89 feet at the north end. Adjoining the filters on the south, a space 12 feet by 89 feet is used for the main entrance and stairways leading down to the pipe gallery and up to the operating floor, and for the steam heating plant and coal bin. Then a space 24 feet by 89 feet is occupied by the forebays and mixing chambers. The remaining area, 96 feet by 89 feet, is used for sedimentation purposes.

Two complete coagulating, mixing, and sedimentation units are provided and connected in such a manner that they can be operated in parallel, in series, or either unit may be operated alone. They are of unequal capacity. The No. 1 unit provides for two-thirds of the total capacity and the No. 2 unit one-third.

¹ Read at meeting of Illinois Section, American Water Works Association, March 10, 1915.

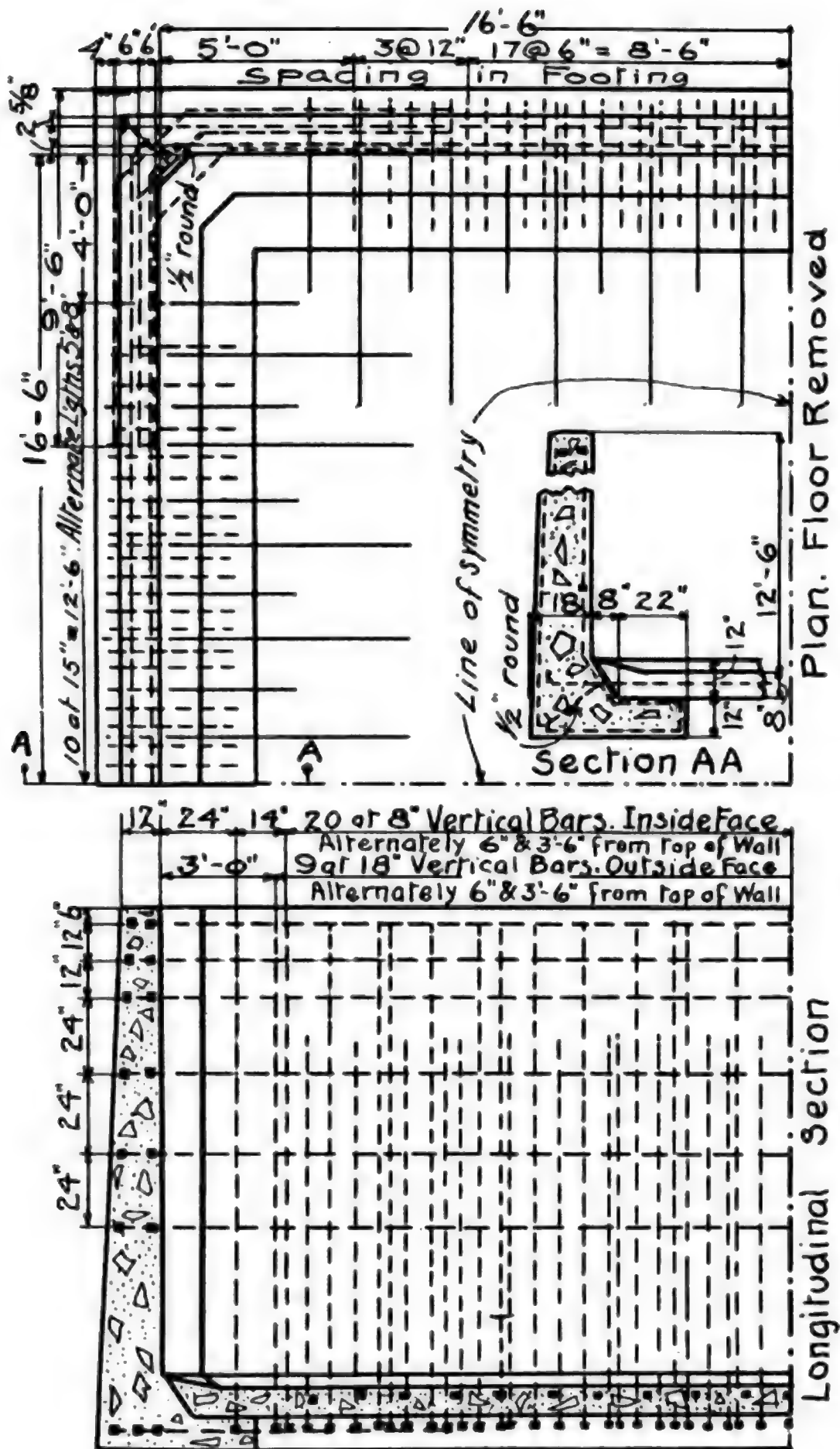


FIG. 1. DETAILS OF REINFORCEMENT OF WASH WATER RESERVOIR. ALL BARS $\frac{1}{2}$ INCH SQUARE, TWISTED, OR EQUIVALENT, UNLESS NOTED







chambers. Large rectangular openings, over the inlet and outlet of the sedimentation basins also provide convenient points for sampling and observation of the operating results.

A well-equipped water works laboratory is also located on this floor. It consists of four connecting rooms having a total floor area of 625 square feet, with well lighted work benches and sinks, and all of the apparatus and utensils necessary for the preparation of media and for the bacterial and microscopic examination of water.

The filters are covered by a one-story brick superstructure which rests upon the outside walls of the filters, leaving the entire area of the filter beds open for inspection. This room is well lighted by means of a monitor roof over the operating floor in addition to the windows in the side walls.

DISCUSSION

MR. W. F. LANGEIER: The official test of the Quincy plant was completed March 1, but inasmuch as the report has not yet been submitted, the speaker wishes to withhold from discussion the results obtained, inasfar as the various guarantees are concerned. One or two unusual operating features, however, were observed and a discussion of them might be interesting to some of the members present.

It was noted that during December the filter runs, or intervals between filter washings, had become materially reduced, and for a few days averaged less than five hours. At this time the turbidity in the raw water was at a minimum and remained constant at 20 parts per million. The experience was similar to one noted during the test of the Evansville, Indiana, plant in 1912 at which time the trouble was ascribed to clogging of the sand by micro-organisms. At Quincy, however, microscopical examinations indicated only small numbers of organisms and moreover the settling basins were quite efficient in removing them. The number and size of the organisms passing to the filters daily was sufficiently small to make absurd the probability that they were directly clogging the filters.

Further investigation showed that the raw water was approximately 100 per cent supersaturated with dissolved oxygen and that the shorter runs were due to gas released in the gravel and under-drain system, probably as a result of the reduced or negative pressure caused by the sealed down draft. In this manner it is possible

to account theoretically for a very considerable volume of gas being released. The extent to which the length of runs may be affected, however, may depend on certain features of filter design by virtue of which the liberated gas is largely made to discharge with the effluent. The further disadvantages of air binding such as the possibility of gravel displacement are well known.

Excess oxygen in both rivers and lakes is a very common occurrence and in all probability much of the trouble being experienced in other filter plants by short runs and attributed to clogging by micro-organisms, is due to this same cause.

In addition to the fact that the raw water was only slightly turbid it was noted that it reacted pink to phenolphthalein indicating an absence of free carbon dioxide and suggesting photosynthesis as the cause of supersaturation. The trouble which lasted somewhat over a week disappeared as soon as the river became coated with ice and snow.

Another feature during the test, which was interesting to us, was the cause of an apparent reduction in the efficiency of the sedimentation basins. The average reduction of bacteria in the settling basins was equal to approximately 85 per cent. During the early part of February this efficiency began to decrease and for about a week a removal of 65 per cent was the best that could be accomplished. This reduced efficiency greatly increased the burden of the filters and it was evident that something had to be done if the guaranteed 97 per cent total removal was to be maintained. The basins had been cleaned only a short time previously and soundings showed that there was only an average depth of a few inches of sludge. There had been no change in the character of the raw water and there seemed to be no good reason for increasing the coagulant dose. It was finally decided to clean the sedimentation basin again, but before this was done several temperature readings were taken. Due to the season of the year it was found that the temperature variations were quite wide. The ice had just left the river a day or two before and much milder atmospheric temperatures were being recorded. The water admitted to the basins was in the neighborhood of 38° but after standing quiet in the basins over night the upper strata continued to rise in temperature. Thus, due to the increased density, a slight overturning, causing some disturbance of the sludge, occurred, and it was believed that this was responsible for the decreased bacterial efficiency. The basins were cleaned and, as

predicted, the average efficiency returned to the normal of 85 per cent.

MR. H. E. BABBITT: In answer to Mr. Langelier's discussion, the writer would like to ask whether there is any reason for suggesting the supersaturation of the water with oxygen. The most common reason advanced for supersaturation of water is the presence of some of the chlorophyceae group, which organism possesses the property of giving off large quantities of oxygen, which is retained by the water. In examination of Des Plains River as much as 300 per cent saturation has been found, with visible indications of chlorophyceae. In his description of his microscopic examination, Mr. Langelier did not mention the presence of an organism of this group. These organisms exist best in quiet water with relatively high temperatures. Violent agitation causes the precipitation of the oxygen. It is interesting to note that the mixing action in the reaction chamber was insufficient to cause the liberation of the oxygen, and that the reduced pressure in the negative head filter is sufficient to affect it. Practically all so-called "positive head" filters have some "negative head" at times, which might cause the troubles explained by Mr. Langelier.

FILTRATION PLANT, CITY OF DECATUR, ILLINOIS¹

BY HARRY RUTHRAUFF

The main filter building covers the filters proper and housing all the piping and appurtenances necessary for the control and operation of the filters. The coagulant storage tanks and feeding devices contained within this building are at an elevation sufficient to permit the flow of the coagulant into the water as it enters the sedimentation basins.

Plans were prepared by William G. Clark, consulting engineer, which plans gave, in general, the necessary dimensions and the arrangement of the various basins and units of filtration, leaving to the bidders the detailing of the equipment for the filtration plant and chemical appliances, in accordance with plans to be prepared by them.

As is usual in these matters, the responsibility for the construction of the work rested on the bidders, and this was especially true as to the equipment; they furnishing their own plans and specifications.

The work was divided into several items upon which bidders could offer in part or as a whole. It was, however, provided that, "those bidding upon items 14, 15, 16, 17 and 18 must accompany their bid with as complete information as possible as to the size, character of raw water, results and cost of purification, etc., of the various plants which they constructed or equipped with appliances relative to water purification for domestic purposes."

As these items comprise the equipment of the plant, it is assumed that the successful bidder would be competent to carry out the various details because of previous experience in this very class of work.

A comparison of the various bids submitted with the items described in the specifications of W. G. Clark, C.E., develops the fact that of the bidders figuring on the construction work, only, items 1 to 13, H. C. Gass was the low bidder, and, of those bidding on the entire items, that is to say, the construction work plus the

¹ Read at meeting Illinois Section, American Water Works Association, March 10, 1915.

equipment, the New York Continental Jewell Filtration Company's bid was the lowest.

Certain changes were pointed out following the submission of bids whereby the low bidder on the entire contract, the New York Continental Jewell Filtration Company, offered to reduce their figures by the amount of \$3000 on revised plans to be made by them, subject to the approval of the consulting engineer for the city, and this proposition was finally accepted under date of April 17, 1913.

Work was at once begun, and progressed as rapidly as was consistent with the development of the detail plans necessary to this character of construction.

This plant has now been in successful operation since September 23, 1914, the representatives of the company advised that the plant was completed and filtered water actually in the clear-water basin. The operator for the city was called in and his instructions started as per contract requirements.

Some difficulty was encountered subsequent to this owing to the fact that the city sewer was of insufficient capacity to carry off the wash water, and this was remedied.

As completed, the following detail of this plant may be of interest:

The excavation was in clay almost entirely, of such a character that the vertical walls cut clean, the deepest part of the excavation being that occupied by the sedimentation basins and the clear-water well, from elevation 990 approximately to elevation 1012.

The plant, outside of the sedimentation basins, occupied a rectangular space of approximately 138 feet by approximately 228 feet, and rested on a 6-inch concrete slab, reinforced with $\frac{1}{2}$ -inch steel bars, crossed both ways, so as to afford strength to carry the side walls and various columns.

The space within the rectangular above dimensioned was reduced by a quadrangle taken from the center of the rectangle, the space thereby eliminated being approximately 71 feet by 68 feet in dimension; and, through this quadrangle, is the entrance to the filter plant galleries and to the filters and to the head house and sedimentation basins.

The space occupied by the two sedimentation basins is approximately 105 feet by 121 feet; and, there being two basins within this space of unequal dimensions, one basin has an inside dimension of 49 feet 7 inches by 100 feet 6 inches, while the larger basin has a dimension of 66 feet 2 inches by 100 feet 6 inches.

These two basins are directly attached by a common wall to the



north side of the filtration plant contained within the rectangle above described; and, on the west side of the sedimentation basins and also attached directly to the north wall of the filtration plant proper, is the head house, which is superimposed above the smaller sedimentation tank in part, and also above a mixing chamber located beneath the head house and directly adjacent to the smaller sedimentation basin; the mixing chamber is 6 inches higher, in order to furnish sufficient head by means of which the treated water can pass from the mixing chamber to the sedimentation basins.

The outside walls of these sedimentation basins are 21 inches at the base of the wall, widening out into footings, the footings being 2 feet 10 inches by 14 inches. These walls taper from a 21 inch base to 15 inches at the top. The roof or deck over these basins is substantially 7 inches thick, resting on beams 8 inches in depth; the top of the slab being at elevation 1018; and the elevation of the floor of the sedimentation basins being at elevation 1000. Consequently there is a depth within the sedimentation basin of approximately 17 feet.

The walls of the sedimentation basins, the floor of same, as well as the beams and the roof, are heavily reinforced with steel bars, the amount of steel used in this portion of the construction being approximately 90 pounds per cubic yard. This is substantially the amount of steel also employed in the reinforcing of the clear-water well upon which the filters themselves are superimposed; the greatest percentage of steel being in the filter bottoms themselves, where approximately 95 pounds are used to the cubic yard.

The combined capacity of the sedimentation basins is approximately 1,500,000 gallons and the capacity of the clear-water well is approximately 3,000,000 gallons.

It will be seen, therefore, that there is in normal operation a period of approximately four hours sedimentation after the treated water leaves the mixing chamber and passes into the sedimentation tanks and, through them, on to the filters.

The actual area of the clear-water basin is approximately 25,000 square feet, and the depth is approximately 17 feet. The clear-water basin extends on either side beyond the filters themselves, and is decked over in much the same manner as described in the case of the sedimentation basins.

The clear-water basin is on both sides of the filters, and also connects through the space below the filters, so that the filter tanks are superimposed above the central part of the clear-water basin.



The filters are superimposed above a relatively small part of the area occupied by this very large clear-water basin, and are supported on concrete beams.

The filter units, six in number, are the air-washing type and are each 25 feet 6 inches by 21 feet 3 inches inside dimension—this being the space actually occupied by the sand bed contained within the filter tank.

The filter tanks are 8 feet 6 inches deep from the top of the filter floor at elevation 1008 to the top of the division wall between the filters, which is at elevation 1016.45.

The walls of the filter building, which enclose the filters in part and house in the operating floor and the pipe gallery underneath, are pierced so as to permit a view from the operating floor to the extreme end of the filter unit, some 25 feet 6 inches, so that the entire filter is exposed to view from the operating platform. During operation the water from the mixing chamber passes through a flume to the sedimentation basins, entering on either side of the solid wall dividing these basins in two, and is controlled by 24-inch sluice gates at each point of entrance. Each of the basins is arranged with baffles, so that the water is forced to take a tortuous course from the point of entrance through each basin to the outlet, where the water, freed in large part of its suspended matter, is collected through another concrete flume located at a higher elevation than the inflowing flume first described. The baffles within the sedimentation basin are wooden construction, fitted in concrete grooves.

In the construction of the baffles within the mixing chamber provision is made so that the water entering there, after receiving its dose of sulphate of alumina, is forced downward and upward to insure as perfect a mixing as possible before entering the sedimentation basins where a horizontal flow is permitted from the influent to effluent flume.

From the sedimentation basins, through the filter influent flume, the water passes by gravity on to cast iron gutters arranged above the sand bed of each filter unit and within the filter area. These gutters are located so as to act like weirs in this connection, spilling the water gently on either side of the gutter with the least possible disturbance of the sand bed beneath. A constant head of water is maintained over the gutters and sand bed beneath during the filtering process.

The water then filters at the approximate rate of two gallons per square foot per minute through the sand bed and gravel under-



lying same and is collected through the strainer system and carried through the header piping to the controllers and thence into the clear-water well, whence it passes by gravity to a sump or suction well located just outside of the pumping house, a distance of some 300 feet from the filter building, and the large pumps supplying the city take their suction from this suction well, and force the filtered water to the city.

In washing the filters, one unit is thrown out of commission at a time, the influent valve being closed and the water within the filter tank permitted to filter down until it reaches a point about 4 inches below the top of the gutters above mentioned. These gutters during the washing period perform the function of carrying off the wash water to the sewer connection, the gutters being connected to a concrete flume so arranged as to collect the water evenly from the seven cast iron gutters located in each filter unit.

After the water is drawn below the gutters, the filtered water is forced upward by a centrifugal pump from the clear well through the header and manifold system and strainers underlying the sand and gravel bed at a rate of approximately $8\frac{1}{2}$ gallons per square foot per minute. Before the wash water is permitted to enter, however, a blower is started in operation, furnishing 3 cubic feet of free air per minute against a head of 4 pounds. The function of this freed air is to break up the bed and agitate same and assist the incoming wash water which follows to thoroughly cleanse the bed, passing off the impurities which have accumulated during the washing process into the gutters and thence to the flume connecting with the sewer, and through the sewer to the Sangamon River at a point below the intake.

As this new plant took the place of wooden filters installed many years ago, there was already installed and located within the pumping station, centrifugal pumps turbine driven, and these pumps now lift the water from the Sangamon River to the mixing chamber, thence through the sedimentation basin and filters to the clear-water well, where it finally reaches the high service pumps.

The coagulant devices are located on the second floor of the head house at an elevation of 1031, in general accordance with the engineer's printed specifications, and consist of two concrete tanks of the approximate dimensions of 14 feet by 7 feet 9 inches by 8 feet. These are the tanks for the storage of the sulphate of alumina and they are equipped with dissolving racks and provided with spray pipes and floats and apparatus for the automatic shutting



off of the water when the solution reaches a determined height in the tank. This is in order to maintain a constant percentage solution when a given amount of sulphate of alumina is dissolved.

This plant is also equipped with hypochlorite of lime devices for the sterilizing of the water after filtration; and this apparatus consists essentially of two steel tanks mounted on steel supports at an elevation similar to that of the sulphate of alumina tanks above described.

The solution from both the sulphate of alumina and the hypo solution passes to duplicate orifice boxes equipped with apparatus for the accurate control of the solution which passes into the raw water at the entrance to the mixing chamber.

The hypochlorite apparatus is equipped also with a 24-inch diameter cast iron dissolving tank mounted over the hypo solution tanks and equipped with mixing agitators, belting, shafting, etc., and into this tank the hypochlorite of lime is placed and forced to become an emulsion before being passed into the steel tanks situated below, where it mixes with water and is stored in a percentage solution through automatic shut off apparatus.

While the sulphate of alumina solution passes to the mixing chamber, the hypochlorite of lime solution passes directly to the outlet of the clear-water basin so as to insure as intimate contact as possible with the clear filtered water as it leaves the filtration plant. The filtered water is thus sterilized as it passes to the suction well.

The building over the filtration plant is of ornate design, with slate roof, steel trussed; the brick used being a dark, hard-burned brick, and the inside of the building being faced with yellow hydraulic pressed brick.

On the operating floor within the building are arranged, at each unit of filtration, operating tables of Tennessee marble, oak panelled, and surmounted thereon, are nickel plated valves which control the operation of the filter, the plant being equipped with hydraulic valves for the purpose of operation; and loss of head gauges of the indicating type giving information as to rate of flow, time to wash the filter, etc.

On the top floor of the head house a large room is provided for storage of sulphate of alumina and hypochlorite of lime. Access is had to this floor by means of an elevator which communicates from the ground floor up to the storage and chemical mixing room, which are on the same floor.

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THE APPELLATE COURT OF THE STATE OF NEW YORK AND THE QUESTION OF ALLOWANCES FOR PAVING OVER MAINS IN VALUATION WORK

BY JOHN W. ALVORD

On March 24, 1914, the Court of Appeals of the state of New York handed down its decision in the case of New York Public Service Commission, First District, vs. Kings County Lighting Company, covering three questions of "going concern value," "paving over mains," and the "annual increase in land values."

The writer is in substantial agreement with the decision of the court in the first and last questions, but in its reasoning over the second question, that of paving over mains, there seem to be vital economic and engineering considerations which the court has overlooked.

It is seldom politic or wise to review the decisions of the courts, even when one feels quite sure that the courts have overlooked important matters in their reasoning. Courts have their responsibilities and difficulties; many subjects come before them which are new to them, yet, which they must pass upon, and as a matter of courtesy and propriety, in matters pertaining to law, they are not properly subject to public criticism from the engineer.

But the work of valuing public utilities requires a very considerable knowledge of at least two fields of experience outside of the law, that of engineering and of economics or finance, and when the courts, by reason of their responsibilities, are obliged to reason in these fields, and do not reason from correct economic assumptions, it becomes necessary to considerably point out why practical

engineering experience cannot at times adjust itself to economic ideas of a judicial origin.

In estimating the reproduction of a utility property, the question has been often raised whether the cost of cutting through and replacing paving over mains should be included. It is not a new question and it is submitted, first of all, that it is not a legal question but one involving engineering fact.

Is it physically possible to reduplicate a plant as of today, having a pipe distribution system in the streets in a modern city with pavements all as of today, without cutting through and replacing the paving? A straightforward honest answer to this simple question will relieve us of much trouble and will clear up many difficulties. It is a question which not only the engineer, but the courts can answer promptly and the answer must of necessity be that in all normal cases a humanly possible reduplication of a property cannot be accomplished without incurring those expenses.

Why, then, should this matter trouble valuers? The answer is, first, that nearly everyone unacquainted with the fundamental principles of valuation but charged with its responsibility is confronted with an uncontrollable desire to reason about value before all the evidence of fact is fully complete and before him, and second, that there is always a tendency on the part of inexperienced valuers to mix up evidence on past or investment cost with evidence on reproduction or present day cost, before either are complete.

It will be the endeavor of this review to show that both of these defects clearly exist in the reasoning of the Appellate Court on the question of "Pavement Costs."

SOME FUNDAMENTAL PRINCIPLES

Before proceeding to analyze the opinion of the court, we may, first of all, define the following economic principles, which it is believed are fundamental, and should constantly be kept in mind.

Proposition 1. "*Property*" is seldom the same thing as "*Investment*."

Proposition 2. *Cost* is seldom the same thing as *value*.

Proposition 3. *Past cost* or *investment* is seldom the same thing as *reproduction cost*, or cost new as of today, less depreciation.

Proposition 1. We find that Webster defines property as "The exclusive right of possessing, enjoying, and disposing of a thing; ownership; an estate whether in lands, goods or money."

A property, therefore, may be acquired by gift, by purchase, or by natural accretion. It may grow with the growth of need for its service or it may suffer decline in value because of lessening usefulness.

Webster further defines investment as follows: "The laying out of money in the purchase of some species of property, usually of a permanent nature."

Now, if a given property was purchased say yesterday, the investment may be the same thing as the property, and the amount of the *investment* may also be under some circumstances, a good measure of *value of the property as well*. But if a property was originally built a great many years ago, and was constantly added to since, or perhaps was inherited by gift from outside sources, or had natural accretions in the meantime, or suffered losses of usefulness, then the *investment* is hardly ever the same thing as the property, nor would it be a just and proper measure of value, and this latter condition is the usual and frequent case in valuation work.

In the business world of today, investment is a term used to denote the money actually put into a property, and is not usually considered as measuring the value of the property itself, and Webster's definition seems to substantiate this usage.

In valuation work, therefore, one should be careful not to use the words "Property" and "Investment" interchangeably. They may on rare occasions be identical, but usually they are applied to quite different things.

Proposition 2. *Cost* is seldom the same thing as *value*. *Cost* is only a good index to value when, as has been said, the thing to be valued has been recently purchased under open market conditions likely to be somewhat permanent.

Cost is otherwise not necessarily *value* at all. A thing may be worth much more or much less than it originally cost. It may also be worth much more or much less than it would cost to reproduce it as of today.

Only the briefest kind of thinking is needed to see the truth of this statement.

Proposition 3. Past cost or investment cost is seldom the same thing as reproduction cost, or cost new as of today less depreciation.

The original investment, for instance, may be largely dissipated by bad judgment, a changing popular demand, or a decline of population or other like influences. On the other hand, it may increase

by socalled unearned increments, by gifts, by good judgment, and strategic location, and by the needs of growing population.

The past cost of a plant and the present reproduction cost less depreciation, can only be identical; usually first, when a property has been recently purchased under conditions of market stability and permanency, or, second, when the appreciations and depreciations of the past investment happen by chance to produce a sum which equals reproduction cost less depreciation.

It is believed that these three propositions are self evident. Further light will be thrown on the practical working of these principles by a more detailed discussion of the opinion.

WHAT IS IT THAT WE VALUE

In valuation work it is important to know, first of all, what it is that we are to value. Are we to retrace the actual cash expenditure that has gone into a property, or are we to value the plant and business of the utility as a *property* and as of today? This is not an engineering question; it is the function of the law and the courts to guide us on this important point, and the courts would perform a notable service if they would construe the law on this point for us in a manner so clear and decisive that further discussion of it or dispute about it would be needless. As it is, about one-half the time of courts and commissions is now wasted in hearing opposing views on this particular question from parties, who, for the sake of temporary advantage, desire the one or the other of these views to prevail in their particular case and for their particular side.

So far as engineers can gather the law from a review of court decisions and opinions, the courts are generally holding firmly to the view that it is the *value of the property*, not the past cost, and *as of today*, not as of yesterday or last year, that we are to find; but occasionally a court will wander back to the past investment theory, as the Appellate Court has in part done in this instance, and thus confuse appraisers, engineers and commissions engaged or about to engage in valuation work.

THE FUNCTION OF THE COURT IN REPRODUCTION EVIDENCE

The court has two functions to perform in receiving and reviewing reproduction evidence:

1. It should scrutinize the reproduction estimates in the light of

reason and common sense aided by the engineering evidence to see that they are made on a basis that is humanly possible and practicably feasible and workable; that nothing is left out of them that would ordinarily be encountered in real life and real work, and that nothing is included in them that is not necessary in fact or in good engineering practice; that they are neither padded out nor skimmed, in a word; that *they are a fair and honest picture of what would really happen.*

This is the engineer's particular domain, and the views of the experienced and practical engineering expert should here receive weight, especially when he shows maturity, experience and fairness in his testimony. The engineer is in effect a court all by himself on this subject, but his decisions must have a reason back of them and must be subject to review.

2. When reproduction, less depreciation, estimates have been fully completed, so that enough cost has been allowed to reproduce the entire property, including the reproduction of the business, then it is the function of the court, aided by the evidence, to reason out the question: "*Is reproduction less depreciation in this case a proper measure of value or a fair measure of value, and if not, why not, and to what extent not?*"

It is here that the Appellate Court has misconceived its problem. It has taken under consideration one of the items belonging strictly to the reproduction estimate and endeavored to reason out of existence an engineering fact that cannot honestly be eliminated, and then with this item alone in mind, the court has endeavored to determine whether it is or is not *value* as applied to the property as a whole.

What the court should have done was first to reason out whether this item was properly a part of the reproduction estimate, and secondly, was it fairly and properly estimated, and thirdly, it should have asked itself: "*Is the reproduction estimate itself, as a whole, a fair and proper measure of value in this particular case?*"

A method of approach, such as is above described, would have placed the court decision on firm and dignified ground and avoided an unfortunate attempt to controvert a fact in the evidence before it, which is ordinarily indisputable.

THE OPINION

To understand fully the application of these economic suggestions, it will be desirable here to quote all of the portion of the opinion in the case referred to relating to the question of Paving Cost, italics marking sentences that will be particularly discussed.

In determining the cost of reproduction the commission allowed \$12,717 as the cost of restoring the pavement as it existed when the mains and service pipes were laid in the streets. The relator claimed an allowance of at least \$200,000 for the cost of restoring pavements subsequently laid on the theory that that cost would have to be incurred if the mains were to be laid today. *But the new payments in fact added nothing to the property of the relator. Its mains were as serviceable and intrinsically as valuable before as after the new pavements were laid.* The controlling considerations under the preceding point also determine this. The rights of the public are not to be ignored. The question has a double aspect. *What will be fair to the public as well as to the relator?*

(Smyth v. Ames, supra). Should the public pay more for gas simply because improved pavements have been laid at public expense? It is no answer to say that the new expensive pavements suggest improved conditions which, though adding to the value of the plant, will not, by reason of the greater consumption, add to the expense per thousand feet of the gas consumed. The public are entitled to the benefit of the improved conditions, if thereby the relator is enabled to supply gas at a less rate. *The relator is entitled to a fair return on its investment, not on improvements made at public expense.* It is said that the mains will have to be relaid. So will the new pavements, and much oftener. Both might possibly be relaid at the same time. The case is not at all parallel to the so-called unearned increment of land, that the company owns. *It does not own the pavements and the laying of them does not add to its investment or increase the cost to it of producing gas.* The cost of reproduction less accrued depreciation rule seems to be the one generally employed in rate cases. *But it is merely a rule of convenience, and must be applied with reason.* On the one hand it should not be so applied as to deprive the corporation of a fair return at all times *on the reasonable, proper, and necessary investment* made by it to serve the public, and on the other hand it should not be so applied as to give the corporation a return on improvements made at public expense *which in no way increase the cost to it of performing that service.*

The Appellate Division felt bound by the decision of the United States Circuit Court in the Consolidated Gas case (157 Fed. Rep. 849), and it is true that such an allowance was made in that case. But the United States Supreme Court held in that case (212 U. S. 19) that the rate established was not confiscatory, and did not pass on the propriety of that allowance. What was said in the opinion on the subject of present value was merely a general statement having no necessary relation to the question now under consideration.

Reviewing the opinion as above quoted, it must be apparent:

1. The reasoning of the court does not seem to show a clear distinction between investment or actual past cost expenditure and the reproduction cost as of today, which latter it is in reality discussing.
2. The court alters engineering facts to fit its reasoning, rather than attempts to fit its reasoning to the engineering facts.
3. The court needlessly increases its dilemma by reasoning about the value of the property as a whole, with only one of the items of reproduction estimate in mind.

THE NATURE AND USE OF REPRODUCTION ESTIMATES

A little thinking on the nature and purpose of "*reproduction cost less depreciation*" as a line of cost evidence, useful in arriving at the value of public utilities, will convince almost anyone not prejudiced in the matter that if this kind of cost evidence is worth anything at all as an aid to valuation, it is because it produces something concrete and tangible; something which can be checked by experience and common sense; something which is so commonly done and so often repeated that engineers at least know fairly well what would happen under a given set of conditions.

A competent engineer, with the proper experience, can tell what it would cost today to reproduce a property, because he is, and has been for many years, reproducing properties. It seems an entirely practicable proposition to him at least, if not to the layman or the court. Once the engineer is directed to estimate a reproduction, he embarks upon a programme, to him not susceptible of violent expansion or curtailment; his reason and experience insist upon the inclusion of every item that must reasonably be encountered each step of the way.

When a court in its opinion deliberately advises the engineer, therefore, that reproduction is "merely a rule of convenience," apparently it says to him: "We, at least, are not bound down to reproduce this property in a way that is humanly possible if the final costs incurred do not seem to our lay minds reasonable." You must not, for instance, buy land that is now held at very much higher prices than formerly, nor must you compute the excessive cost of laying pipe in congested streets if once, long ago, perhaps, you could have operated in grass grown and deserted thoroughfares only just opened up from adjacent farm lands. Continuing this

logic, it says in effect you must seriously consider the laying down of pipe in paved streets without cutting through the pavements or replacing them, because it does not seem to us that the public should pay rates on this kind of expense.

Certainly engineers cannot acquiesce in any such loose ideas of "Reproduction," as an engineering estimating process.

WHAT IS REPRODUCTION

To the engineer, the reproduction of a property as of today can mean one thing and one thing only, and that is the entire elimination of all methods which are not humanly possible. We are not living in the days of an "Aladdin's lamp," we have no magic wand, nor will we be listened to with respect by the courts if we attempt to formulate a fairy story.

To reproduce a property from an engineering point of view is to proceed in a manner which engineers commonly use to overcome the obvious obstacles that all new construction encounters. It must be done under conditions as they exist today, or will exist in the near future, during a reasonably rapid period of construction. The life work of the engineer is to estimate in advance what the obstacles to such a process will be, and what it will cost to overcome them, and what will be humanly practicable to accomplish, and to advise the engineer that certain obstacles to a reproduction which he can clearly see must exist, should not be estimated because the result will be too high or too low, is as great a fallacy as to direct him in his estimates to use three as the product of two times two.

To compute the cost of only a part of a structure and call it "reproduction" is worse than a misnomer, for if the facts on which valuation reasoning are based are incorrect, the valuation reasoning itself is vitiated.

Some courts and commissions confuse themselves at times by calling this item "the value of pavements over mains." This is not a correct designation. The engineer in figuring the cost of reproducing a plant does not compute the value of pavements over mains at all. He computes the cost of the excavation work of cutting through pavements as an obstacle, laying his pipe thereunder, and the cost of the work of replacing the pavement in as good condition as it was before, and this is a very different thing from valuing a pavement, for it has no connection with the cost or "value of a pavement, itself."

HOW "REPRODUCTION" WORKS OUT

Now, it is quite idle to argue that a present day plant can be reproduced without ordinarily incurring such an item as we are here discussing, and the court, fortunately, has not attempted such an argument.

Where then, arises its difficulty?

Obviously because it has lost sight of the true nature, limitations and use of that line of cost evidence known as "reproduction cost," and is dwelling on past cost or investment, which is entirely a different thing.

Let us inquire first how reproduction as of today should be worked as a practical matter.

Reproduction should present a faithful and practical picture of what the city or utility company would face, if they had to build a new plant now, but like the existing plant in all respects. Reproduction less depreciation, therefore, shears away and casts aside from the original investment the following losses:

Losses to the Utility, Gains to the Public

(1) Obsolete structures which although they have served their day are now useless.

(2) Expenditures and investments which though perhaps they seemed wise at the time they were made have since proved to be mistaken.

(3) The higher prices for materials and machines which may have prevailed in the past.

(4) Investments made for population which may not have developed, or developed in other directions than were expected.

(5) Cost of appliances rendered valueless by reason of improvements in the arts.

(6) The wear and tear of the plant.

(7) Changes in public demand, producing obsolescence.

(8) Inadequacy of original plant due to rapidly increasing population.

(9) All other depreciations and losses from whatever cause they may have occurred.

THE OTHER SIDE OF THE STORY

Now, it must be argued in all fairness and justice, that if we are to thus wipe out, by the reproduction of the plant as of today, all this kind of past investment which may have been made honestly and in good faith, every consideration of fairness and justice requires us to face the fact that utility properties when considered as being now recreated, must take fully into account all the obstacles which they did not originally have to confront. Among these obstacles may be mentioned:

Gains to the Utility, Losses to the Public

- (1) Increased cost of land.
- (2) Increased prices for labor and certain materials and often the high cost of living.
- (3) Difficulties connected with installing a plant amid a more dense and exacting population.
- (4) The necessity of conforming to police regulations and city ordinances made necessary by increased traffic and the public convenience.
- (5) The necessity in underground distribution systems of meeting and avoiding an increased number of other utility conduits, such as sewers, gas or water, telephone or telegraph conduits, service pipes, heating mains, and the numerous pipes which in a more developed city, crowd the subsurface area.
- (6) *The necessity of cutting through and replacing pavements.*
- (7) The necessity of passing under steam railroad tracks, street car tracks, bridges, viaducts, and other improvements not now possible to avoid, but perhaps nonexistent at the time of original construction.

Clearly, if we must, by the force of correctly reasoned and carried out reproduction, eliminate all the obsolete expenditures, the mistakes of the past, the depreciation which property has suffered, we must, as well, find the cost of reproducing the property under the present conditions, with full allowance for such obstacles as the present conditions impose upon us. In reproduction we cannot be just, and neglect, on the one hand, the things which favor the property, and, on the other hand, include those things which are unfavorable to the property. If we are going to dispense with the obstacles which a present day reproduction must meet by some

process of "rubbing an Aladdin's lamp," then, to be fair and just we must also include in our cost estimates the past obsolescence, that is, expenditures for structures which have disappeared, and immediately we do this *we are not reproducing the property at all but are investigating its past history from the investment point of view.*

REPRODUCTION IS A SEPARATION FROM THE PAST

The reproduction method has nothing whatever to do with the past. It is true that recent past experience is our guide in deciding what proper costs are to be used in a reproduction, but such recent past costs are considered only as they aid the judgment in arriving at what the present and near future cost conditions will be. Reproduction, if it means anything at all, means that the engineer is to estimate the cost of a theoretical new work, just as he estimates the cost of any actual new work he may be charged with. To mix actual past costs into reproduction costs, without a review as to whether they are similar to present costs, is a fatal state of mind, and opens the door, especially with the layman, to all kinds of confusion and unreason. Past cost data is only data, and as data it is only of value as it helps us to determine what the present or near future cost would be if the property had to be built new beginning today. The nearer to the present, therefore, that we have data on past cost, the more useful such data usually is in helping us to formulate the future cost of reproduction estimating.

Reproduction a Complete Entity

Reproduction when complete is an entity, a complete whole. Unless it is complete it is dangerously deceptive as a line of evidence. To estimate what it would cost in part to rebuild a property, and then stop and try to reason from that incomplete reproduction the full value of such a property is to start from a false base. Such partial estimates are especially dangerous when the courts or the appraiser does not observe that they are not complete. If one estimates the cost to rebuild a house up to the top of the first story, how will that very much help him to find the value of the two story house he is reproducing and wishes to value? He must reproduce the cost to complete the whole house and then reason whether the house is worth that much or not.

The besetting sin of valuers new to the art is to estimate re-

production partway through, and then stop and try to reason about value of the whole property. They do this often because they think of reproduction as a final summing up and they get afraid they will be led to some conclusion by the reproduction formula to which they do not want to come, so they stop in the middle of things and wrestle with value of the property as a whole when they have no business to be thinking of anything but the reasonableness of the reproduction items.

There can be no formula for reasoning out value.

Some of the mental difficulties which the court encountered in trying to reason value for the property as a whole from partial reproduction items can be well observed in the following quotation: "But the new pavements, in fact, added nothing to the property of the relator."

Is this or is this not true?

Some simple questions can be asked which will apparently throw light upon the question.

If a city desired to build its own municipal gas plant in this instance, would the fact that the utility company's pipes were already under the pavements give them any special value in its eyes?

Would a utility distribution system be likely to have as much value for sale or as a basis for an issue of bonds in an unpaved city as a paved city?

Do pavements over mains facilitate the installation of competitive conditions, or do they deter them?

If a city which never had a gas or water plant but which was well paved should decide to install one, would it cost more or would it cost less because the streets were paved?

If a city had a new gas or water plant installed and great expense was incurred in cutting through and replacing pavements, should the public properly pay rates on this expense or should they escape making a fair return on this portion of the cost thereafter?

An honest answer to these questions would appear to destroy the conclusion of the court on this question.

FAIRNESS TO THE PUBLIC

The writer has been asked several times on the witness stand by commissions or counsel: "Do you think it is right that the public should pay return on the value of paving over mains?" and he is

accustomed to reply, "Yes, if reproduction is found to be a proper measure of the present value of the property, and no, if reproduction is not such a measure."

This kind of an answer is necessary because the question presupposes that reproduction less depreciation is a final formula for the value of the property as a whole. It is in reality only one of the facts helpful to a determination of such value.

Continuing our analysis, we find the court further says: "The rights of the public are not to be ignored. The question has a double aspect. What will be fair to the public as well as to the relator?"

Setting aside an objection to this sentence that there is no time in valuation matters when one should forget the double aspect of the question and what will be fair to the public as well as to the utility, let us inquire how the allowance for paving, so called, is unfair to the public. It is granted in reproduction estimate that the public ordinarily paid for the paving and it is conceded that the company ordinarily does not own it.

The key to this doubt about fairness lies entirely in the misconception of what the item is estimated for, and how it is to be used, as has been shown. It is not for the "value of the pavements" at all, but it is part of the natural cost of reduplicating the property under present conditions, and it has been shown that in a logical reproduction as of today, this increased difficulty to pipe laying cannot be avoided.

If, then, there is any unfairness about this item at all to anybody, *it is because the entire reproduction less depreciation method of fixing value is unfair*, and not because any one necessary item of it is unfair.

Now the question as to whether the entire reproduction method is a fair or unfair method to apply in any given case is an entirely proper one to raise; in fact, no valuation is properly made and completed unless this question of the fairness of the whole reproduction method to any particular case is thoroughly investigated.

WHEN REPRODUCTION IS UNFAIR TO USE

It very frequently happens that reproduction less depreciation is entirely unfair to one side or the other. It is at times unfair to the public in the following instances:

1. When a utility company has installed in construction far greater,

more costly or more numerous structures than it needed reasonably to have installed.

2. When the population and demand have diminished in the course of years so that there is no longer any need for so large a works.

3. When the existing works do not adequately meet the changed conditions of the public need but still are efficient for the purpose for which they were originally designed.

4. When the builders were guilty of extravagance, wastefulness, or misjudgment, dishonesty or graft, resulting in too unreasonably expensive structures or machines.

5. When the prices for labor and material at the time the reproduction estimate is being made are all abnormally high, due to boom periods or acute market scarcity of materials.

Other situations in which reproduction less depreciation are unfair to the public might be added to this list.

Again, it is unfair to the utility company:

1. Where it owns and controls valuable processes not generally available, or, say, the sole source of supply, as, for instance, in water supplies from a limited number of desirable springs, or a peculiarly favorable geological or physical opportunity not readily duplicated.

2. Where skillful designers and experienced builders have accurately forecasted the changing needs of the public or of the future and economically provided properly for it with wisdom, skill, and good judgment.

3. Where conditions of great hazard and risk have arisen and have been successfully overcome by ingenious and skillful engineering design costing but little to introduce.

4. Where careful study and prudent investigation have produced an engineering work that results in special savings in operation not ordinarily available.

5. Where the prices for labor and material at the time the reproduction estimate is being made are largely depressed due to panics or periods of temporary depression.

WHEN IS REPRODUCTION A FAIR MEASURE OF VALUE

In valuation work, it may be said to be a fundamental principle that the cost of reproduction as of today in a manner that is humanly possible and practicable to the engineer, less the depreciation of the property *must be the least value which can be put upon the property when the following conditions obtain:*

1. That the utility's product is needed by the public.
2. That the service is satisfactory.
3. That the city is prosperous and growing.
4. That no serious mistakes of engineering or finance have developed in the past history of the plant.
5. That the cost of the service to the consumer is less than any substitute service.

Under the above conditions, it is obvious that if the public utility property, whether owned by the city or the company, were suddenly wiped out of existence, its value to the community would be the cost of restoring it under existing conditions, i.e., in the near future, including the losses in revenue sustained while so doing, and, of course, all in a manner humanly possible as an engineering problem. When so estimated and restored, its cost would be the least possible value that could be put upon the property. The greatest value which the property could then have would be the cost to the consumers of installing a supply in the next most available way, in other words the worth of the service to the consumer demonstrated.

SHALL WE RETRACE AN INVESTMENT OR VALUE A PROPERTY

It is to be regretted that the Appellate Court, after making so clear an argument for the inclusion of going value, and after showing in that argument that it considers that reproduction was the up-building of a new similar property as of today, should so reverse its reasoning when taking up the matter of pavement costs, for in the latter argument its mind was clearly on the past cost and history of the property rather than on the reproduction which it is discussing.

Three times in the opinion quoted it uses the term "investment," while only once near the beginning does it use the word "property." "The relator is entitled to a fair return on the investment."

And again: "It does not own the pavements, and the laying of them does not add to its *investment* or increase the cost to it of producing gas."

"It, reproduction, should not be so applied as so to deprive the corporation of a fair return at all times on the reasonable, proper and necessary *investment* made on it to serve the public."

Now the term "investment," as has been shown, is used to describe the cash which is usually put into an undertaking or has been put into such an undertaking in the past, and we have already quoted Webster's definition.

It is obvious that the term investment is not synonymous with value. An investment in a property may produce a value as time goes by much greater than the actual money expended or it may become a total loss.

The term "investment," therefore, as applied to a utility being valued, must necessarily relate to the money actually expended in the past to build up the property.

Now it is quite evident not only from the use of the term "investment," but by the entire method of expression and argument, that the court in writing its opinion was thinking of the actual money that had been expended in the past. But the subject under discussion is reproduction in the present, an entirely different thing.

If the court had decided on reviewing this case that investment or actual past cost was the best way to measure value of the property as a whole in this particular instance, then it is under no necessity to discuss reproduction at all, because reproduction has no bearing at all on past cost or investment, and if the court wished to use the basis of its past investment as a measure with which to value the property, then it can properly reject the item of paving if it were presented to it, because the cost of cutting through and replacing paving does not enter into past or investment cost unless the pavement actually existed at the time the pipes were originally laid.

But the court in this case is actually reviewing evidence presented to the commission to show reproduction estimates as of today, and in reviewing this evidence comes upon the stubborn fact that a reproduction as of today must include overcoming certain obstructions which did not originally exist, and it proceeds to utilize arguments against these obstructions proper enough in discussing past cost, but entirely improper in discussing present reproduction cost.

This is creating an entirely useless and needless dilemma, because of the lack of clear distinction between past or investment cost and reproduction cost.

DO PAVEMENTS INCREASE THE COST OF GAS

Incidentally it may well be pointed out that the pavement over mains, as an engineering fact, do increase the cost of delivering gas, if not producing it. In the city of Chicago alone, maintenance, and operating repair work is seriously increased, because the equiv-

alent of from six to eight miles of full width pavement are necessarily torn up and replaced every year in the ordinary course of repair and maintenance work to the gas pipe system, and it is indeed hard to see how this necessary expenditure does not increase the cost at least of delivering gas.

Much more might be said here upon the legal status of past cost and reproduction cost as two distinct lines of inquiry from which to reason value, but such line of thought is not entirely proper in this review, which seeks to confine the question to its economic and engineering aspects.

IN CONCLUSION

In making this analysis of the opinion of the Appellate Court in this case, the writer is very far from taking a critical attitude for the mere sake of being a critic, or of controverting the opinion of an honored court. The writer has the utmost respect for the duties, responsibilities and difficulties under which the courts labor, and is firm in the belief that the courts have in the main enunciated a body of sound reasoning which is going far to solve the difficult questions which are raised in valuation matters.

It is, therefore, only with the hope of being helpful and of placing judicial decisions in engineering or semi-engineering fields on a sound basis of reason that he has undertaken the present unpleasant task.

The Appellate Court is by no means the only responsible body that has had difficulties with this perplexing item. Most of the commissions and engineering experts have been much troubled over the matter in the absence of fundamental guiding principles, and the writer is free to confess that for a short period in his early attempts to solve the "pavement cost" question, he, too, partially adopted the conception to which the Appellate Court has seemed to come. It was only by thinking out fundamental methods, applicable alike to all conditions, that the conclusions herein set forth were reached. and the opportunity of again presenting them to those charged with appraisal duties is here undertaken in this specific instance only in the hope that further light will be thrown upon a difficult matter.

DISCUSSION

MR. FRANCIS H. LUCE: Mr. Alvord has accomplished something that is interesting to a good many, by emphasizing the fact that figuring reproduction new is only a means to an end. It would seem that our engineers are responsible in a large measure, through the fact of their dealing so strongly with this reproduction value new, in confusing the minds of people as between the two things, reproduction value, and actual value. We all know that they have not a very close relation. Our experience in building a plant, for instance, is that much of the extension work is done during periods when the material is high and labor is high, and the cost amounts up. In a plant the speaker has in mind most of the material that has been used has been put in during periods when prices of pipe have, probably, ranged from \$33 to \$40 a ton. An engineer who attempts to figure the value of that plant by figuring reproduction value probably would not arrive at much nearer than one-half of the value of the plant today, not the investment, but the actual value. The investment might have been double or more than double what the reproduction new would be, but the actual value today is double what the reproduction value would be, because its earning capacity is there.

Mr. Alvord has done a valuable thing in emphasizing the fact that we are playing on this one string too much, that is, the reproduction value new, and thereby confusing the mind of the Court with the idea that this has a great effect upon the total value, whereas, as Mr. Alvord has said, it is simply a guide in figuring, as a means to an end.

MR. F. W. CAPPELEN: Mr. Alvord is absolutely correct in his contention that the cost of paving must be included in the cost of reproduction. The question has frequently come to the speaker's notice. Assume that a gas company has a 6-inch main laid on several blocks when there was no pavement. Later on the gas company finds that it is absolutely necessary in order to do business to have a 16-inch main on those various blocks. When the 16-inch main is put in, the street is paved with asphalt or some other kind of pavement; the gas company must go to the city and ask permission to relay that main; take up the pavement and open the street. Then the city afterwards replaces the pavement and charges the com-

plete cost of such replacement to the gas company. There have been a great many cases of that nature in Minneapolis, where the average cost of replacing pavement is about \$2.50 per square yard. That is charged to the gas company, of course, and is a fair charge, and the gas company must put it against its operating expense. Now, considering a new proposition altogether, you are reproducing a 16-inch main, you are not reproducing a 6-inch main; you are reproducing also a new pavement, and you have to provide for it. It seems peculiar that the courts can look at it in any other way than the one that Mr. Alvord has suggested.

MR. H. C. HODGKINS: The paper covers a great deal of ground, but the thought which seems most prominent is that the author has assumed to criticise the decision of the court. Many of our legal friends would doubtless call that effrontery; yet there is no good reason why the engineering profession should not point out the right way as well as the legal profession, except that the legal profession through the courts has the last say.

The idea used to prevail that a lawyer was supposed to be thoroughly versed in architecture, engineering, science, medicine, and theology, in fact, was supposed to know everything. They have come to know that there are some things which they have to learn of the other professions; for instance, the paving question came to the speaker's knowledge, in Chicago, in connection with the telephone company. They were required to have their wires underground, and whenever a street was opened and a new pavement laid, they took the opportunity of getting their conduits into the ground, although they would perhaps have no use for them for the next 5 or 10 years. Could any one undertake to say because they took advantage of that opportunity, that thereby the conduits were not worth more money when they came to be used than though they had not taken advantage of that opportunity?

Clearly it appears that the pavement over that conduit added to its value to the extent of what it would have cost if they had delayed putting it in until they had to cut through the pavement.

The profession has been criticised somewhat for just such expressions as are in this paper. However, we have learned that the courts do sometimes reverse their decisions, and that a correct conception of engineering questions is not always obtained and does not always appear from the decisions. Therefore, the author of this paper is

quite justified in maintaining that the right line of reasoning was not applied in that judgment. Although the judgment of the Court of Appeals will be quite generally accepted, yet it is quite possible that a better conception of the question would bring about a better result, and perhaps greater justice to utility corporations and the valuations which they ought to receive.

MR. R. B. HOWELL: Will Mr. Alvord please state what was the proper method of arriving at the sum of \$200,000 for this pavement? Was it so much per square yard, or so much per foot of pipe?

MR. JOHN W. ALVORD: The author is not familiar with the detailed figures in that case; it was a gas case (Kings County Gas and Electric Company), but assumes that that was the cost of cutting through the pavement and replacing it, not reproduction value. That question was not submitted to the court.

MR. R. B. HOWELL: It seems that reproduction value based upon that premise would not be correct, unless there was taken into account the period of time for which that main would probably remain under the pavement. For instance, if the life of the pipe was exhausted with the exception of say 3 years, you can say that the cost of repaving figured in that manner would be unjust to the municipality, because in a period of 3 years the pavement might have had to be cut and relaid, and a new main laid, or there might be a case where the main was inadequate. As the speaker understands it, in nearly all the cases where the cost of repaving is added, this fact has not been taken into consideration; and it must have been such considerations as these that led the court to the view which it took; in any other case the question is theoretical. In any other case you have to take into consideration all the facts, and whereas justice and law are not synonymous, the law not being any more exact than any other science, they have probably realized that here was a dispute that should be settled with justice, and the court took this view; and upon that theory alone you can sustain the position of the court. The fact that there is a belief that has spread throughout the country that engineers are somewhat responsible for the payment by municipalities of excessive prices for public utilities which they have purchased lays upon the engineering profession a duty to see to it that those doubts are not all resolved in favor of public utilities corporations.

MR. C. B. SALMON: The question considered by the court in the Kings County case did not refer in any way to the age or the condition of the pipe under the paving or the pavement itself; as that was taken care of in the valuation and depreciated to its present worth. The paving would certainly take no longer life, and in all probability was depreciated on the basis of its own life—in which case when worn out it would have to be replaced by the city and not by the water or gas company.

In the lower New York Court of Appeals case all paving over mains whether placed before or after pipe laying was allowed, as well as present value of land and "Going Value." In the appeal to the higher State Court the cost of laying pipe under pavement was not allowed unless the pipe was laid after the pavement. The cost of paving over mains was not considered unless the mains were laid after the paving was placed. The present value of land and "going value" were sustained.

Now the question referred to by a speaker, that in the course of a few years, four or five, another pipe might have to be laid, would not enter into this decision, for the reason the pipe and pavement have already been depreciated to present value, and the company would have to replace their pipe if worn out, the same as they would replace a piston in a pump, or a flue in a boiler when worn out; and that would come under operation or out of surplus account and they would not be allowed to make additional value for returns.

If you go farther in the line the gentleman has spoken of, it would bring out a great question; but it is a fact, which engineers will not attempt to dispute, that because until lately depreciation was not charged off, there were no water works constructed in the earlier periods, except in very special instances, like perhaps Los Angeles, in rapidly growing cities, under favorable conditions, where the water works ever made any money. It was not considered that the rate established under a franchise would produce a profit sufficient to take care of all unexpected losses. The experience of the last 30 years has shown that early investors were fooled, because, except in a few special cases, the demand did not increase fast enough or largely enough to take care of the property, to give the investor or the builder, if he still owned his property, a fair return from the inception of his plant to the present date; allowing for depreciation. For that reason the "going value" of the early cost of securing an income equal to the present income is now con-

sidered and allowed by all State and Federal Courts. If the net receipts of the plant have finally become sufficient to pay for those early losses and depreciation to present value and still show a surplus and maintain the property with fair return, then the proper way is to reduce rates but not omit "going value." Some courts hold it obligatory to value "going value" or set aside the valuation entirely. So the question of the rate in the franchises does not by any means assume or prove that it was anticipated that that rate would take care of all the early losses and the unexpected and unknown things that have since occurred in the construction of waterworks and the present demands of the public.

MR. W. A. PATTON: In regard to the pipe in the gas plant that has 3 years yet to live, the difference in the value of new pipe and the pipe that has but 3 years to live is covered in the depreciation. Thereby the city only pays a certain per cent of the original value in taking the plant.

But if the court rules that the theory of reproduction and depreciation shall be the basis for estimating the value, then it is a plain duty to allow the company the benefit of the changed conditions where the value of the pipe line is increased on account of being located under pavement that was built after it was laid.

A house may be built one mile from a city and possess a certain value; 10 years later the city may be built around the house and thereby immensely increase the value of the house. No one would question that the owner of the house is the beneficiary of that increase. In the same manner the owner of a pipe line should be the beneficiary when its being favorably located under the pavement increases its value and the city should pay for that increased value when it takes the plant.

Mr. Alvord in his paper referred to situations where machinery that was obsolete would not be considered. If a company in operation for years past gets no consideration for an investment amounting to large sums for machinery that has outgrown its usefulness, but which was used for building up the business, it would not be proper to say that the company should lose all that and still get nothing for the going value of the business that has been built up. This is a question on which this association ought to go on record; it is a question important to every person that has a dollar invested in a water works plant; it is a question which we know that the courts in some

cases have been wrong in ruling upon; it is a question that we ought not simply to pass over, but this association ought to go on record so that through its action the courts might be enlightened and adopt the conclusions set forth in the paper which Mr. Alvord has read to us, and which should be concurred in as the sense of this association.

MR. R. B. HOWELL: Let us take, for instance, a 6-inch water pipe, say it costs \$1.25 a foot to lay and say that 3 feet or 1 yard costs \$3.75, and the paving \$2 a yard, or a value of \$5.75 for laying the pipe and the paving. Let us suppose that this particular pipe had depreciated so that it was worth 25 cents a foot, that paving would still cost \$2 to relay, and then the municipality would be paying \$3.75 for pipe that was worth 75 cents in the ground, \$3 for the pavement and 75 cents for the pipe. Now is that just to the municipality? It is evident that it has got to take up that pipe shortly and relay it and then it has to replace the paving and pay for it. If the pipe were new, the pipe in the ground might be worth to the municipality \$5.75; but if the pipe only had a short life and was worth but 75 cents, then certainly the municipality ought not to be charged \$2 for the paving as it would have been if the pipe were bought new. It is probably considerations of this character that entered into the judgment of the court, or as somebody has said, courts are instituted for the purpose of starting disputes, and those disputes are not always settled with regard to actual justice.

If we take that view of the courts, and the courts take that view of themselves, then it must be realized that they are going to take into consideration factors of this character and not pass them by, and very properly. The court has to seriously consider whether it would be justice to the public under such circumstances to assess the full value of relaying paving over mains that might have had but a short time left to live.

MR. MORRIS KNOWLES: The speaker feels that the association owes a debt to Mr. Alvord for drawing so clear a line of demarcation between different yard sticks for measuring value; and for calling attention to the necessity when using one method of calculation of going right through with it to the end, and of avoiding confusion by refraining from occasional jumps to some other method.

Estimated cost of reproduction new is only one of several yard

sticks; historical cost, shown by the books of the utility, or as estimated on the basis of original conditions and prices, is another. But, when estimating the cost of reproduction, we should carry it through to its logical conclusion, estimating, as the author has pointed out, the cost of construction at the present time, under present conditions, and at present normal prices. The conclusion is unavoidable, therefore, that in estimating cost of reproduction we must take into consideration the fact that pipes are laid under streets that are paved.

When we have the answer we must then decide how we will regard it, and how we will use it. This is a separate step and a distinct problem by itself, and one on which there may reasonably be a difference of opinion. The speaker would certainly not agree with one of the previous speakers that the lawyers will have the last say in this matter, for within recent years there have been numerous instances in which the courts have advanced beyond their earlier position in accordance with progressive public opinion. Such changes have been particularly well illustrated by decisions relative to social legislation, such as Workmen's Compensation and laws regulating the hours of labor of women and children. It is clear therefore that the courts change as the times change, as you and I and the man on the street become educated and progress to new points of view. There is no valid reason therefore why the decision of a court should be looked upon as the last word and the end of progress. Certainly we have as much right to disagree with some decisions as we have to differ in our opinions with other men, even though we may agree to live for the time being in respectful obedience to the decision whose wisdom we question.

Neither is the speaker ready to admit the contention of the last speaker that because cost of reproduction is often higher than original cost, the engineer making the estimate is attempting to inflate value. The conscientious engineer must pursue his work to the end whatever the conclusion; but it does not necessarily follow that fair value must be based exclusively or even principally upon estimated cost of reproduction. Fair consideration must be given to all other measures of value available; and since there is something of the spirit of partnership in the relation between the public utility and the community which has given it the use of public property and permitted it to share in the right of eminent domain, it is frequently proper that fair value shall be fixed somewhere between

actual investment and reproduction cost, so as to permit both utility and community to share in the increments of value which have resulted from the growth of both.

MR. J. N. CHESTER: The speaker can hardly take Mr. Howell seriously in his building up from \$1.75, or \$3.75 and then adding to that \$2 for the cost of paving, for, if he depreciates the paving along with the pipe, as he should do, he will reach a fair conclusion.

MR. EDWARD WEGMANN: Two or three years ago the speaker had to make a valuation of the property of two large private water companies, to determine the rate charged; and in those cases, working under the orders of corporation counsel of the city of New York, the court ruled that the companies were entitled to the cost of the paving which had been there when they laid the pipe. A great many million dollars has been paid for those pipes over and above the original cost. The instructions were to allow the paving in every case, and the cost of taking the pavement up and putting it back. Has that been reversed by the decision mentioned in the paper? That was the decision of the Court of Appeals of the state of New York in the Consolidated Gas Company case, which was a famous case.

MR. JOHN W. ALVORD: That case, as it is recalled, approved of the inclusion of the cost of cutting the pavement. The Consolidated Gas Company case went up to the Supreme Court on the question of the inclusion of the cost of cutting the pavement, and it was held that it was to be included in the estimate of cost all the way through.

MR. C. B. SALMON: Perhaps there is a little misunderstanding here as between the United States Supreme Court decision in the Consolidated Gas case and the Kings County case before the Appellate Court of New York. The Consolidated Gas case was previous to the Appellate Court case. In the Consolidated Gas case the court's controversy was very largely upon the value of the land, the company contending that it was some \$5,000,000 or \$6,000,000 more than the city valuation; and the case was carried up largely on the value of the land; and the United States Court decided in favor of the present and the company's value; whereas the value of the pavement over mains was not made much of and at that time

was a small item as compared with the value of the land. In deciding the case, the court did not refer to the pavement but allowed it in the gross valuation and decided the case upon the present value of the land as decided by the lower courts, including what cost there was valued in the pavements; but in the King's County case, the value of the paving put in after the pipes had been laid was refused; so that while the Supreme Court of the United States allowed in the Consolidated Gas case the amount of the paving which the company claimed; the decision itself did not go into any details, except to include "going value" and present worth of real estate. That case, is the case, gentlemen, you may wish to refer to, as some of our commissions are trying to take up the original cost of the land as the only value to be allowed in the valuation of a utility property; but you have only to refer to the United States courts which invariably have decided that in estimating the value of the land, it is the present value of the land, that is to be taken into consideration, not the original cost.

If the reconstruction of a utility, depreciated to the present value, is the proper method of valuing such a property, then Mr. Alvord's criticism is both eminently proper and respectful. That it is a proper method of valuation the Federal courts have repeatedly decided. Reconstruction carried to the logical end certainly must rebuild the present works as they now exist. If there is pavement over the pipes it must be torn up and replaced, and the cost of doing this would have to be considered in rebuilding the present plant by reconstructing a new like plant.

It is claimed by cities that the company should not be allowed this increased value, because the city added it, by putting the pavements over the mains without any cost to the utility; but the United States courts have decided that a utility is entitled to any enhanced value that may have come to the property "whether caused by the growth of the city or otherwise."

The growth of a city necessarily demands pavements for the convenience of the public. Water mains are usually ordered by the city in advance of pavements because water is a necessity, and pavements follow by growth of the community as a convenience: often water mains so ordered do not pay the community for a long time. After pavements are put down, values increase; because larger and better houses are built requiring more water, and increasing the water receipts, thus making a water main under a paved street more

valuable than on an unpaved street. In addition to the reconstruction theory, the water or gas mains actually become more valuable by this enhancement, created by paving, in the same way that land values increase on a paved street. For this reason state and federal courts allow present value, instead of original cost, on land, buildings, machinery, and pipes, whether higher or lower than original cost. A proper valuation of a utility should be made by men experienced in that line. Judges may or may not have had that experience; therefore, with all due respect, values might properly be left more largely to the judgment of the engineer.

MR. J. W. LEDOUX (by letter): The term "cost of reproduction" is in the writer's opinion rather unfortunate. It should be the "estimated cost of reproduction." We generally conceive of a cost as something definite, and therefore calculations of valuation made by engineers or others should have their proper designation. They cannot be anything but estimates unless they are taken from the actual records of the case under consideration.

There is only one element of valuation that is infallible and unchangeable, and that is the "past cost." As soon as we depart from that procedure in determining valuation we obtain figures that will vary according to the purpose for which the valuation is to be made; but, nevertheless, this is the plan adopted by the courts and in consequence, by engineers. It is generally assumed or found that the past cost cannot be obtained with certainty, because the books have not been properly kept, or the records have been lost, or the results show something so abnormal as to be unacceptable to the courts or the valuers; therefore, it becomes necessary to use some other method of arriving at the valuation, and it will vary according to the circumstances:

(1) If the water company has a franchise based on exclusive rights in the territory and fixed rates, and the municipality has no right of purchase by condemnation, valuation would be logically based on some capitalization of the net revenue.

(2) If the water company does not have exclusive rights and the municipality has the right at any time to purchase by condemnation, the valuation would be based on the estimated cost of reproduction of the physical plant and the business.

(3) If a municipality or state has the right to change the rates of a water company and the valuation is to be made for this pur-

pose, then it would seem that the most logical method would be to determine what has been the investment of the water company to bring the water works to its condition at the time of the valuation. If the figures of actual expenditures are unavailable, or if they are such that the valuator considers them abnormally high or low, according to reasonable average practice, it should be his duty to make the proper adjustments but to keep in mind at all times the conditions under which the plant has been developed, on the assumption that the water company is entitled to a fair return on the investment from the beginning. Logically in this case, the valuation of the works would be lowered if the water company had been earning too much and raised if it had been earning too little. The personnel of ownership, the sales or purchase of stock or bonds should have nothing to do with this method of obtaining the valuation, and on the same line of reasoning, depreciation would be ignored as well as the subsequent laying of pavements over the pipes except in so far as they affect the operating expenses and the cost of always maintaining the works in a 100 per cent condition.

If a capable, experienced and fair minded valuator be given a ~~case~~ ^{case} to determine what is exactly fair between the two parties he would have to take the circumstances of the particular proposition, and this would certainly be the ideal method of obtaining valuation, but the common practice is for each party to have an array of partisan witnesses who naturally present all the points to aid its own particular side, and the court must arrive at what is fair from all this conflicting testimony.

MECHANICAL ANALYSES OF SANDS¹

BY PHILIP BURGESS

To the sanitary and hydraulic engineer the period of 1890 to 1895 is of great importance, because it marks the beginning of the present very remarkable growth of water purification plants especially in the United States. English, or slow sand, filters are adapted to the purification of the comparatively clear waters of the Eastern States, where this work received its first important impulse, so that much of the original investigation work along the lines of water purification was directed to the study of filters of this type. The Massachusetts State Board of Health stands conspicuously in the position of pioneer in this work, and its reports, especially for the years 1890-1892, mark a distinct period in the growth of the art of water purification.

Early investigations of this Board and of other workers indicated that the efficiency of a sand filter depends very much upon the size, or range of sizes, of the sand grains composing the filtering material. Consequently, it was necessary to devise some efficient method of analyzing the filter sands for comparative purposes, and the method described by Mr. Allen Hazen in the report of the Massachusetts Board for the year 1892 was developed to meet the requirements which existed at that time. This method proved so satisfactory that it has been generally adopted by the sanitary engineering and chemical professions up to the present time.

Within recent years, however, the engineering field requiring accurate analyses of sands and gravels has broadened very greatly. A comparatively new type of filter, called the American or "Rapid Sand Filter," has been developed and has been found to meet the average requirements in the United States, outside of the Eastern

¹ During the discussion on this paper a motion was made by Mr. Paul Hansen, seconded by Mr. J. M. Diven, that a committee to consider revision of methods of sand analysis be appointed; the motion was, after some discussion, and the suggestion of several names for members of the committee, put and carried.

states, more efficiently than does the English, or "Slow Sand" filter. Experience indicates that the size of the sand required for a rapid sand filter differs materially from that generally used in the construction of a slow sand filter. While the methods of analysis employed for sand used in the slow sand filter may readily be adapted to the analysis of sand required in the rapid sand filter, the usual method of expressing results in terms of effective size is not entirely satisfactory, because the range of sizes of sand permitted in rapid sand filters frequently is very much less than is commonly used in the filtering material of slow sand filters.

Moreover, recent engineering literature contains many references to a still further and, perhaps, more important use for mechanical analysis of sands and gravels, namely, in the selection of materials required for concrete mixtures. It is now recognized that arbitrary standards or proportions for mixing the aggregates required to form water-proof or dense concrete are no longer satisfactory, or to be recommended, because of local differences especially in the size and ranges of sizes of grains or particles composing the large and small aggregates.

A still further use of mechanical analyses of sands is in the preparation of asphalt mixtures such as are required for certain types of street pavements.

In view of the very rapidly increasing use of, and necessity for, accurate analyses of sands, it is remarkable that recent engineering literature contains so little matter describing or discussing the proper methods of making such analyses. On account of the lack of such standard methods, it is not surprising to note that specifications covering the use of such materials frequently are extremely weak and ambiguous. Such weaknesses, of course, tend to increase the cost of work and frequently result in a very unsatisfactory quality of material.

Another feature of the situation, to which the present lack of standard methods of analysis contributes, is the fact that the manufacturers of apparatus required to separate materials into specified sizes, or range of sizes, find it extremely difficult to satisfy the specifications and requirements of engineers in this respect. This is particularly true in regard to the preparation of sands required for filtering material. It is seldom that a local community does not have available, within reasonable distances, satisfactory material as required for the preparation of a filter sand, but, on account of

lack of knowledge on the part of the local contractors, or of the engineers in charge of a particular piece of work, such local sands are seldom used and filter sand is nearly always imported, perhaps from considerable distances and at large expense.

In view of the increasing importance in the matter it is believed that the attention of the engineering profession may at this time very well be directed to the development and adoption of standards of apparatus and procedure required for the mechanical analyses of sands and also to securing a uniformity of terms required for specifications of materials.

It is believed that some of the confusion which has resulted in the matter has been from the adoption of such terms as "Effective Size" and "Uniformity Coefficient" which are applied to sands used for filtering material. These terms, of course, have little or no significance to an ordinary contractor or to the manufacturer who is in the business of screening and sizing sands and gravels.

Moreover, a further confusion has arisen from the endeavor to use the actual sizes of the sand grains rather than the sizes of the openings in the screens. It was early recognized and appreciated that there may be considerable variations in a sieve used for testing purposes in respect to the diameters of the wires and the spacings of the mesh. Consequently it was considered that the nominal spacings of the meshes per inch were of no consequence in determining the separation of a sieve. This view of the matter, of course, required a determination of the relation between the average diameter of the openings and the size of separation of a sieve, or more properly the determination of the actual size of separation of a sieve. Because but few engineers have available the equipment required to standardize sieves, in many instances the results of analyses have been reported in terms of numbers of meshes, or wires, per inch. This method of expressing results, of course, is indefinite and inaccurate, because wire cloth used in the manufacture of sieves frequently varies both as regards sizes of wires and the number of meshes per inch. Within recent years, this difficulty has been appreciated by manufacturers who in some instances have endeavored to clear up the matter by producing standard testing sieves made in accordance with recent standard specifications and with certain arbitrary intervals of spacings between the individual units. By such means, it is hoped to fix definitely the diameter of the openings in testing sieves. Recently, the Bureau of Standards of the

Department of Labor and Commerce at Washington has adopted standard specifications covering the manufacture of certain testing sieves; also, when solicited, this department stands ready to rate and standardize testing sieves at a nominal cost with a view of determining the actual average diameters of the openings.

The writer believes that the engineering profession should adopt a standard method and standard apparatus for making mechanical analyses of sands and gravels. It is believed also that simplicity and accuracy in reporting the results would be obtained by revising the methods commonly used at present to report such analyses. Possibly that feature which would tend most to clear up the situation would be to change the standard of measurement from the size of the sand grains to the size of opening in a sieve. In view of the fact that testing sieves can now be obtained which are composed of wires of uniform sizes and of accurate spacings, in both directions, it follows that such sieves will, within reasonable accuracy, contain openings of a certain definite size. Testing sieves which do not come within such requirements as are contained in the specifications of the Bureau of Standards should be rejected.

One of the difficulties to be encountered in such a change of standard would be to compare previous analyses with present or future requirements and conditions. Some years ago, while at Philadelphia, the writer made a great many tests to determine the sizes of separation of two nests of sieves; also to determine the relation between such sizes of separations and the diameters of openings in the screens. The average ratio of size of separation to size of opening was found to be 1.10 and was a constant within the limits of accuracy which can commonly be secured in making a mechanical analysis of sand.

Some of the finer sieves examined contained twilled cloth and not directly woven cloth. The average ratio of the size of separation of the twilled cloth to the average diameter of the openings was found to be 1.18. This comparatively large ratio of separation to diameter of opening in such sieves has been stated to be one reason why there is no constant relation between the diameter of opening and the separation of a sieve. As a matter of fact, however, no difficulty need be encountered in obtaining directly woven wire cloth even for the fine sieves, so that a nest of sieves may readily be obtained with a practically constant ratio of sizes of openings to sizes of separations throughout.

In determining the relation between the separations and openings in the sieves at Philadelphia, there were counted over one quarter million sand grains and the work extended over a period of two months. The sieves were rated and rerated until the curves of analyses obtained by examinations of the same sample of material by the two sets of sieves coincided throughout their entire length. Great care was taken, also, to secure accurate measurements of the diameters of the wires and of the number of meshes per inch in both directions, from several parts of the area of the cloth.

In the following table are shown ratings of different nests of sieves with which the speaker has from time to time been familiar:

Sizes of Separation of Representative Testing Sieves for Sand Analysis.

MESHES PER INCH	SIZES OF SEPARATIONS IN MILLIMETERS					
	A-1	A-2	B	C	D	E
4				5.6		5.7
10	2.00	2.00	2.19	2.15		2.09
14				1.45	1.45	
18	1.04	1.05	1.07			
24	0.79	0.81	0.81		0.86	0.78
30	0.58	0.60	0.61	0.57	0.58	0.57
40	0.45	0.46	0.48	0.46	0.40	0.45
50	0.31	0.33	0.34	0.37	0.30	0.34
60	0.24	0.30	0.30	0.23	0.27	0.29
80	0.187	0.197	0.190	0.195	0.195	0.193
100	0.153	0.161	0.168	0.160	0.150	0.156
140	0.121	0.117	0.126	0.115	0.120	
200	0.085	0.087	0.104			

The sieves indicated in Columns A-1 and A-2 were used in the office of Fering and Fuller of New York. The ratings in Column A-1 were obtained by counting and weighing the sand grains. The ratings in Column A-2 are of the same set of sieves and were made subsequently by the speaker by measuring the diameters of the openings in the screens and applying the factor 1.10 to the sieves Nos. 10-100 and 1.18 to the sieves Nos. 140 and 200. The ratings in Column B were made by Mr. A. E. Kimberly at the Sewage Testing Station of the city of Columbus, Ohio. The sieves of Columns A and B were made by the same manufacturer, at the same time, under the same specifications. The ratings in Columns C and D

were obtained by the speaker for two nests of sieves used at Philadelphia. The ratings in Column E were determined by Mr. J. W. Ellms for the sieves used in testing the sand required for the Cincinnati Water Purification Plant. Mr. Ellms rated these sieves by measuring the diameters of the openings and applying the above mentioned factors to determine the sizes of separations.

The table serves to illustrate some of the reasons why it is believed that the subject of standard apparatus and standard methods for analysis of sands and gravels is of great importance to the engineering profession at this time.

Attention is drawn also to the marked differences in engineering specifications and requirements for the preparation of sands used for filtration purposes. Frequently such specifications are limited to an expression of the maximum and minimum effective size and maximum and minimum uniformity coefficient.

These terms mean nothing to the ordinary contractor who must furnish the material. It is obvious that the whole question of obtaining satisfactory material would be very much simplified if the specifications would read that a satisfactory sand would be one which contains not more or not less than certain specified quantities as separated by certain standard sieves. Such standard sieves would be available for the contractor, or manufacturer of the material, as well as for the engineer in charge of the work who, under present circumstances and conditions, has the matter almost entirely in his own hands. This is true in regard to specifications for sand required not only for filtering material but also for any other purpose.

It is significant that the difficulties of the present situation are appreciated by some of the manufacturers of screens and testing sieves who have, in some cases, in their trade publications, gone into a discussion of testing sieves rather thoroughly with a view of meeting the demands of the engineering profession. Special reference is made to catalogue A entitled "Testing Sieves," published by a manufacturer of Cleveland, Ohio. This company has placed on the market a set of testing sieves, the finest of which conforms to the No. 200 sieve described in the standard specifications of the Bureau of Standards at Washington, D. C. The intervals between the wires, or the diameters of the openings in the sieves, increase in a certain definite ratio, namely, the square root of 2, or 1.414. This ratio has certain obvious advantages because it permits the

selection of sieves which give accurate ratios of separations of 1.1414, 2, or 4 to 1. These sieves are described in the following table:

Standard Testing Sieves

MESH (NO. PER INCH)	DIAM. OF WIRE (INCH)	OPENING (INCH)	OPENING (MILLIMETER)
	0.149	1.050	26.67
	0.135	0.742	18.85
	0.105	0.525	13.33
	0.092	0.371	9.423
3.....	0.070	0.263	6.680
4.....	0.065	0.185	4.699
6.....	0.036	0.131	3.327
8.....	0.032	0.093	2.362
10.....	0.035	0.065	1.651
14.....	0.025	0.046	1.168
20.....	0.0172	0.0328	0.833
28.....	0.0125	0.0232	0.589
35.....	0.0122	0.0164	0.417
48.....	0.0092	0.0116	0.295
65.....	0.0072	0.0082	0.208
100.....	0.0042	0.0058	0.147
150.....	0.0026	0.0041	0.104
200.....	0.0021	0.0029	0.074

It is believed that the adoption of a standard nest of sieves along these lines by the engineering profession would help very materially in securing uniformity in the expression of results of mechanical analyses of sands.

It is, also, believed that there would be a great advantage in simplicity of expression of results of analysis or in the form of specifications covering the preparation of filter sands to the effect that 10 per cent of the sand passes, or shall pass, a standard sieve No. 35, or a standard sieve having an opening of 0.417 mm. diameter, as compared with the usual statement that a sand has, or shall have, an "Effective Size" of 0.46 mm. Moreover, the term "Effective Size" has no significance whatever outside of its application to a filter sand and of itself alone the term is of doubtful value as applied to sands such as are frequently used for rapid sand filters. The range of sizes is believed to be much more significant.

In conclusion, it is the writer's wish to call to the attention of the members of this Association that the matter of standardizing methods of making analyses of sands is of importance to all water works men who have to do with water purification problems. If contractors and water works superintendents understood more about the matter, frequently it would be possible to construct and maintain filtration plants at much less expense than is now required. The matter of obtaining satisfactory filtering material frequently is extremely simple, but has been made difficult by the methods of analysis commonly employed, and by the requirements as to size described in engineering specifications. There is no probability that the engineering profession as a whole will adopt the terms now used in the mechanical analyses of filter sands for the analyses of sands and gravels used for other purposes such as proportioning concrete, paving mixtures, etc., so that uniformity and standardization of the results of such analyses can be obtained only by a revision of present methods.

DISCUSSION

MR. PAUL HANSEN: The Association is greatly indebted to Mr. Burgess for bringing the matter of revised methods of filter sand analysis to its attention. The speaker would like, however, to emphasize that we should not discredit entirely the method that has been hitherto used. Mr. Hazen's method has been developed on scientific lines and will probably continue to be the basis for any revised standard that may be adopted. That Mr. Hazen's method has proven to be a reasonably satisfactory method for sand analysis is attested by the very fact Mr. Burgess mentioned, namely, that there has been very little literature published recently on the subject of sand analysis.

It is also questionable whether the full interpretation of a sand analysis can be reduced to such simple terms that it can be readily made by general contractors. However, there can be no doubt about the fact, that the time has come when certain modifications are desirable, especially in view of the fact that it is possible now—which was not the case formerly—to obtain sieves that are made very accurately and uniformly.

MR. F. C. LEOPOLD: There is no question but that it would cost a good many localities unnecessarily for sand used in their filter

plants by reason of the method of analysis. There are a great many localities where perfectly acceptable sand can be secured for filtration purposes and where fairly satisfactory screening plants are established. The only necessary addition to them would be inexpensive screens to secure the grade of sand necessary. But when you put certain requirements of sand analysis up to the sand producer he throws up his hands and does not want to have anything to do with it at any price; consequently, we have to pay anywhere from \$2 to \$10 a ton freight on sand that very often could have been had elsewhere at \$1.50 freight rate, or less.

It does not make any difference to the filter builder, of course, he does not have to pay it, but whoever is building the plant has to pay it. Still there is absolutely no excuse for requiring something which does not add anything to the efficiency of your plant, and which would prevent a man who can do so from furnishing you material that would adequately fulfill the requirements.

There is another thing that the speaker wants to call attention to, and that is an idea in the minds of some engineers that there are only one or two places that filter sand can come from, and that it does not make any difference whether it fulfills the requirements of their specifications or not, if it does not come from those points it is not satisfactory filter sand. We have found that in our experience, not once, but a number of times, we have been able to produce sand that would fulfill in every way the requirements of the specifications, but because certain filter sand had been demanded, as that or its equal it did not comply with their specifications, necessitating an additional expense anywhere from \$2 to \$10 per ton freight rate, which is absolutely unnecessary. The speaker fully agrees with Mr. Burgess in his idea that something ought to be done to eliminate the necessity for paying freight rates unnecessarily on sand for this purpose when it can be gotten locally, and just as efficient in every way.

MR. WILLIAM M. JEWELL: There is no doubt that a great saving, as Mr. Leopold said, can be made in the water works filtration plants by changing to the standards that Mr. Burgess has recommended, and the average sand contractor is very much befuddled over terms which he can never understand, because he has had no technical education; and furthermore, such requirements do not always seem to have a legitimate basis.

Experience has shown that if the uniformity coefficient was based on a higher percentage, say 40, it would be very much better for mechanical filters of rapid type than if based on 10 per cent of the finer material.

In rapid mechanical filters, the washing of the filters is getting down to a point where from three to four minutes' application of water is supposed to be sufficient; and the more we can approach an ideal or uniform size of sand, the better it is going to be for efficiency, when you come to shut off the wash water and restart your filter, you are not going to have a mixture all through the filter bed or the fine material on top. As Mr. Burgess has well said, a standard of 10 per cent effective size is all right for slow sand filters, but it is a little bit out of date. The speaker agrees with Mr. Burgess that the standards ought to be changed.

MR. GEORGE W. FULLER (by letter): The writer is in sympathy with Mr. Burgess' viewpoint in the effort to secure simplification and standardization of sieves used for the mechanical analysis of sands.

Unquestionably it has been a fact in the past that contractors, sand dealers and others have experienced marked difficulty in knowing what was desired by engineers who specified the effective size of sand, uniformity coefficient, and limitations in quantities of sand particles either above or below a stipulated size expressed in fractions of a millimeter. Any procedure which will materially improve this situation, as handled by large numbers of people who now grope more or less in the dark, should certainly be welcome.

On the other hand, it should be kept clearly in mind that methods of measurement used for a period of 20 or 25 years should not be put aside lightly until important practical experience gained in past years, with more or less unsatisfactory methods, can be translated for the benefit of the technician with substantial certainty into terms of the new and improved method of measurement which it is desired to adopt.

It is the belief of the writer that the methods can be improved without sacrificing materially our practical grasp of the significance of the fund of knowledge accumulated in the past.

MR. WM. B. FULLER (by letter): The author has brought to the attention of the writer a matter which has for several years occupied his thoughts, and he is in hearty accord with the suggestion

toward the abolition of specifications concerning effective sizes and uniformity coefficients, and the adoption of language more easily understood by contractors and others who have to furnish the materials.

In specifying sands for filter plants, and in mixing concrete, the writer has long since abandoned these confusing terms, having discovered that they acted as bugaboos to the contractor, who, in consequence, bid much higher than was necessary, for fear of money losses, due to possible impracticable enforcement of petty details.

The writer has no doubt that many thousands of dollars would have been saved to communities had all specifications been written so as to state the allowable percentages passing through certain standard sieves. In the absence of such standards the writer has been accustomed to specify the percentages passing a certain number of meshes per lineal inch made from a certain size wire. It is obvious that if a standard mesh was adopted the specifications would become clearer and less cumbersome. Experience in this line leads the writer to believe that the community would receive the benefit of lower costs for equally good work.

The writer is fully in accord with the author's views that, within the limits of such accuracy as can commonly be secured in making a mechanical analysis of sand, a constant ratio can be adopted between the size of separation and size of opening; his own experience leads him to believe that the personal equation of the operator, the methods, and rate of shaking, and other factors, will produce greater variations in the calculated rated sizes, than would be produced by the use of standard sieves by different operators. Great care and thought, however, should be expended by many persons familiar with the use of test sieves before a definite standard should be adopted.

The recommendation of the author towards the adoption of the standard proposed by the Cleveland manufacturing firm should be carefully considered, as the system is very inconsistent in many respects, not the least of which is the fact that such sizes have been selected for the cloth as are not of standard make, and, in order to maintain the openings in a constant ratio, the ratio of width of wire to width of opening is very erratic. This is particularly noticeable with their 6 and 10 mesh and their 28 and 30 mesh.

The writer considers it very necessary for standard sieves that not only the openings of adjacent sieves should bear some definite

mathematical relation to each other, but also that the ratio of width of opening to width of wire should bear some ratio, and, more important than all, the standards adopted should be of weaves from standard sizes of wire. Most wire is now drawn to either the old English or the Frown & Sharp gauges, and, in addition, only certain of these gauge sizes are available to the trade without special orders for large quantities. Standard sieves should therefore be made from stock wire, if possible, otherwise but few firms could afford to keep a stock of wire for this particular purpose, and as a consequence, many sieves would be sold which were not standard.

In connection with standard sieves, it is also necessary to adopt standard methods of shaking, and in this line a mechanical agitator, giving both a semi-rotary and undulatory motion, is desirable.

The writer is of the opinion that the ratio of one sieve opening to that of the next smaller size in the same series should vary gradually through the series from a larger ratio for the larger openings, to a smaller ratio for the smaller openings, and that at the same time the ratio of the size of wire to the size of opening used in any sieve should gradually decrease as the openings become larger.

It would be very desirable that this matter of standard sieves should be taken up in coöperation with the Bureau of Standards of the Department of Commerce at Washington, and with the American Society of Testing Materials, who it would seem would be the logical society to promulgate a standard, as any standard adopted should be adjusted so as to be of use in all industries.

MR. ALLEN HAZEN (by letter): It may be that when one has proposed a method that has been in very general, in fact, in almost universal use among those having to do with the subject for a period of twenty to twenty-five years, he ought to be willing to see the method discarded and replaced by a newer one. The writer is in this position with reference to the method of mechanical analysis, which is the subject of Mr. Burgess' paper. However, he feels disposed to insist that it be demonstrated that the proposed changes represent a real advance before they are adopted, and in the present case he feels that some of the changes suggested by Mr. Burgess would be unfortunate, and would not mark an advance in the art.

Mr. Burgess speaks of the necessity of having the standards equally applicable to all the various purposes for which mechanical analyses are required. In this the writer fully concurs. The same definition

of size of particles should, if possible, be used in discussing very fine sediments and silts; in discussing materials to be used as foundations; in discussing filter sands; in discussing materials for concrete mixtures, and in discussing materials for asphalt mixtures.

We can here, perhaps, well divide the subject into two parts. In the old method of sand analyses developed by the writer, the size of grain was defined in all cases as the diameter of a sphere of equal volume. This method is an absolutely general one, applicable to all cases, and the writer sees no reason why it should be abandoned at this time.

The second part of the subject relates to the terms "effective size" and "uniformity coefficient." It should be understood that these terms were originated for the purpose of defining filter sands and for no other purpose, and it is to be recognized that they are not necessarily or presumably applicable to discussing sands, gravels or silts for other purposes. If they prove to be useful for some other purpose, there is no reason why they should not be used, but there is no presumption that they have any significance whatever with reference to materials for foundations or asphalt mixtures, or sands and gravels for concrete.

Mr. Burgess' principal proposition relates to the first part. He proposes to abandon the use of sizes of particles which pass or fail to pass the screens, and to substitute therefor the size of mesh of the screen itself.

It may be proper at this point to state that the method of rating sieves originally proposed and in general use is to put a representative sample of sand upon the sieve to be rated, to shake it in a specified manner, and at the completion of such shaking, to give it a slight further shaking, during which the material passing is separately caught, and finally to determine the grain size of these last particles. Experience shows that these particles are nearly all of the same size, and when that size is determined it establishes the size of separation of the sieve. The size of the particles, in most cases, is determined by weighing a certain number of them and computing the average weight, and from that the average volume and the diameter of a sphere of equal volume, which is the basis of the statement. This is a process that can be carried out with quite definite results, and it is the foundation of the whole scheme of rating and grain sizes that has been used.

In practical operations, a method of comparative rating is also

used and has been found helpful. By this system, one set of sieves, dedicated to that purpose and rated with the utmost care by the method first described, is used for comparison with other sieves for which ratings are desired. The same identical sample of sand is sifted through the standard sieves and through those to be rated. This is repeated with several samples of sand selected to show the points of separation of the respective sieves.

The results of the analysis of each sand by the standard sieves are plotted on logarithmic paper, 20-inch base, a large scale being used to allow of the utmost precision. It is found that the analysis of natural sands plotted in this way, including about the finest half of the material by weight, plot in nearly a straight line on this paper and it is possible from the sieves in the standard set to get a very accurate determination of the position of this line at all points. With this line plotted, the percentages of materials passing each of the new sieves are found upon it, and in the opposite direction is found the corresponding size of separation for that sieve.

The size of separation determined in this way is determined with reference to the original or standard sieves. Very great precision is obtainable with careful manipulation. For instance, the difference between a sieve having a separation 0.200 mm. and one having a size of separation of 0.205, should be unmistakably apparent. This degree of accuracy is all that is required for practical purposes.

This method of comparative rating is described at some length, because it has an important bearing upon the question of substituting the size of mesh for the size of separation of the sieve. The size of mesh is computed in a somewhat theoretical way by ascertaining the number of meshes per inch, best obtained by counting blue prints made from the wire cloth, by measuring with a micrometer the diameters of the wires and by computing from these data the average openings in the two directions. They are practically never square. The wires differ in diameter by quite appreciable amounts among themselves and no one has yet found how to weave cloth so that the space between successive wires is always the same. Under these conditions, some openings are larger and some smaller than those computed, and the majority of holes, instead of being square, are more or less out of square.

The particles of sand instead of being spheres are irregular in shape, the long, middle and short diameters for ordinary sands being

approximately in the ratios of 4, 3 and 2. When such ordinary sand grains are shaken upon a mesh that is not quite square, it is found that the size of grains passing is determined by the longest dimensions of the mesh and not by the shortest one. In other words, if the mesh is 0.28 mm. in one direction and 0.30 mm. in the other direction, it is the 0.30 that controls, and the size of separation of such a sieve will be substantially the same as of another sieve 0.30 in both directions, and also substantially the same as the size of separation of sieve 0.30 x 0.25. This is not exactly true, but it is approximately so.

However, even when this matter is taken into account, there are always variations in the sizes of the openings that affect to an appreciable extent the size of separation of the sieve. For instance, if from a very carefully woven piece of wire cloth, woven for the express purpose of making sieves, and with the greatest attention to having it uniform throughout, a dozen pieces are cut close together and made into sieves and examined by the system of comparative rating mentioned above, substantial differences among the sizes of separation of the sieves are invariably found. These differences are not accidental, such as might be accounted for by differences in manipulation. They are real differences that can be substantiated by passing any number of samples of sand through the same sieves and concordant results can be obtained.

Under these circumstances, to abandon a definite and quite accurate method of designating the size of the sieve and to substitute therefor a less accurate method, is certainly not a step in advance. Examinations of various other kinds of materials involve much labor and equipment. If accuracy is to be secured in such examinations, it is imperative that the fundamental ideas upon which accuracy is based should not be neglected nor abandoned.

It is further to be noted that sifting is only one of various methods used in determining the size of particles. For instance, it is not practically applicable to particles much less than 0.10 mm. in diameter. For all smaller particles elutriation or microscopical methods must be used. Such small particles have little significance in filtration work, but in studies of materials for other purposes they are exceedingly important, and it seems desirable to the writer that the method used should be a general one that does not need to be varied for different purposes. The size of sieve opening being

about 90 per cent of the size of particle, it would be necessary, in order to keep the results consistent, to use an expression to describe the size of smaller particles something like this:

Size being about 90 per cent of actual size and taken to represent what the size of sieve would be which would pass particles of this size, if such a sieve could be made and used.

Similar definitions would be necessary to describe larger particles separated by round openings in metal discs, which are more convenient and accurate for particles 2 mm. and over in diameter.

The writer is interested in Mr. Burgess' statement that the term "effective size is not entirely satisfactory, because the range of sizes of sand permitted in rapid sand filters frequently is very much less, etc." The writer begs to point out that this is precisely the point where the uniformity coefficient is useful. The need of having some method of expressing the degree of variation in the sizes of the particles of sand was recognized when the present method of sand analysis was devised, and it is no less essential now than it was then. In the light of all the experience in twenty-five years since, and with a study of recent development in the art of statistics and methods of statistical expression, the term "uniformity coefficient" seems to measure up very well to modern standards. It is possible that the words "uniformity coefficient" could be now improved upon. On the other hand, the modern equivalent "coefficient of variation" has a precise definition and it should be used only for exactly what it is defined to mean in books of statistics.

The data of sand analysis cannot be treated in a way so that the "coefficient of variation" can be easily computed. The "uniformity coefficient," however, which is easily determined by the methods now in common use, would be proportional to the "coefficient of variation," if that could be computed, and is equally as useful in the interpretation of sand analyses, and as long as it is not identical, it seems better to retain a distinctive expression for it.

The effective size was defined as such that 10 per cent by weight of the particles were smaller than it. This has seemed to many as a somewhat arbitrary and rule of thumb procedure. However, it was based upon very good underlying data.

The filtering materials for which data were available at Lawrence when the method was adopted comprised sands with quite a wide range in uniformity coefficients. Data for frictional resistance, capillarity, etc., for these sands were available. Comparative studies

showed that if 8 per cent was taken as the limit instead of 10 per cent, an unduly great weight was given to the effect of the finer particles upon the physical properties of the material; while if 12 per cent were taken, the effect of the finer particles was inadequately represented. The Lawrence data were very clear upon this point, and the 10 per cent limit was selected because this brought all the materials for which data were then available into their correct relative positions with respect to frictional resistance and capillarity.

There is no reason to suppose that 10 per cent is a precise mathematical limit always true of all materials. Nevertheless, practical experience extending over twenty-five years and to many thousand samples of sand and the collection of large amounts of additional data on physical properties, has failed to show any way in which the original expression could be improved in a substantial manner.

The writer is interested in the improvement in the methods of weaving cloth for sieves and of the suggested arrangement for a set of standard sieves. The arrangement proposed seems an excellent one, and if it can be carried out to give sufficient regularity in mesh opening, he would heartily support it, but would urge that the sieves nevertheless, be rated in all cases and that the actual size of separation be used in discussing the results, rather than the supposed size of separation computed from the nominal or even the measured average mesh and size of wire.

The writer also notes the suggestion that engineering specifications should be written so as to provide the percentages that should pass sieves of certain sizes. Mr. Burgess has evidently overlooked the fact that all the earlier specifications for sand and gravel drawn in the writer's office, and frequently copied in other early specifications, were drawn in the way which he now proposes. For instance, the Albany filter specifications required that, "The grains . . . shall be of the following diameters; not more than 1 per cent by weight shall be less than 0.13 mm. nor more than 10 per cent shall be less than 0.27 mm.; at least 10 per cent by weight shall be less than 0.36 mm., and at least 70 per cent shall be less than 1.0 mm. No particles shall be more than 5.0 mm. diameter."

The method was a perfectly satisfactory one and has much merit. As the years have gone by and contractors have become accustomed to the terms "effective size" and "uniformity coefficient," these have been written into the specifications and have taken the place of the longer schedules which had previously been used. The writer

thinks that very little practical difference has been made in this change. No doubt, it is true that many contractors do not fully understand all the nomenclature of sand analysis. That is true of many other parts of our specifications.

After much experience in securing sand under specifications covering, perhaps, the purchase of as large a quantity of sand and at as low an average price as would be represented by the experience of any other office in the country, the writer is unable to say that lack of understanding of these methods by contractors has been a serious obstacle in the prosecution of the business. It is certainly true, as Mr. Burgess suggests, that there are numerous excellent deposits of sand stock all over the United States that have not been used, and that much money could have been saved by more knowledge and better appliances. However, that is hardly the fault of the method of sand analysis. A general raising of the intelligence and information of those who have to do with this subject must be the foundation of improvements in this respect and of a more complete use of natural resources.

MR. PHILIP BURGESS: Before presenting this paper to this Association, the speaker submitted a considerable number of copies to engineers interested in the subject with requests for their opinion in regard to the subject matter contained in the paper. He was interested to note that in nearly all cases these engineers concurred in the opinion that the methods now in use for analyzing sands and the specifications frequently used by engineers to describe sands may very well be revised, simplified, and standardized. It is, of course, true that any step towards a revision of standards or methods of testing, which have been generally adopted for long periods of time, should be taken slowly and only along the lines approved by the majority of those interested and affected.

Nearly all of the engineers who have expressed opinions in the preceding discussion and otherwise have agreed that the use of terms such as "effective size" and "uniformity coefficient" in engineer's specifications is not to be recommended because these terms are not understood by the manufacturers or contractors who have to supply materials in accordance with such specifications. There remains, therefore, but two possible methods of describing sands or gravels in regard to their size or range of size, namely, by specifying certain definite ranges of sizes of grains or by specifying certain definite

percentages by weight which may be retained upon or pass certain standard sieves. At the present time there are no such standard sieves so that it is necessary to define the range of sizes of grains or particles.

It is, therefore, true that specifications along the lines of certain percentages by weight to be retained upon or to pass certain standard sieves would be a radical departure from current practice which specifies sizes of particles regardless of size of openings of screens through which such particles may pass. It is this departure from current practice which, of course, should be approached with hesitancy and assurance of advantage before it is taken.

The speaker has called attention to specifications of a certain set of standard sieves which define the sizes and spacings of the wires with a view of illustrating what in his opinion is required at this time, namely, a standard nest of sieves for making mechanical analyses of sands. He does not wish to be understood as arbitrarily recommending the adoption of this particular set of standards although the use of a definite screen ratio has obvious advantages. Mr. Wm. B. Fuller has called attention to certain features of these standards which are objectionable, and especially to the fact that there is not a definite ratio between the sizes of openings in the meshes and the diameters of the wires. As Mr. Fuller very well states, this ratio is important and affects the ratio of the size of separation of a sieve to the average opening in the sieve. It is doubtless true that, in any standards that may be adopted, it will be desirable to maintain as closely as possible a definite relation between the size of opening and diameter of the wire in each sieve. As Mr. Fuller also states, the standards adopted should be based upon wire cloths which are readily attainable from manufacturers.

Mr. Wm. B. Fuller and Mr. Hazen both have called attention to the causes of differences in the determination of the size of separation of a sieve; such differences may be attributed to differences in the sands used for rating; in the personal equation; in the method and rate of shaking, and in other factors. Mr. Hazen very well states that it is possible to obtain very accurate precision in determining the separations of sieves by using careful manipulations; and that, for instance, a difference between a sieve having a separation 0.200 mm. and one having a size of separation of 0.205 should be "unmistakably apparent." The speaker agrees with this statement provided that it is qualified to refer to the use of the same sand by

the same operator using always similar procedure. However, this, of course, is not universally the case, because different operators must use different materials composed of sand varying from sharp to round grains, and because operators do not now use the same procedure and care in obtaining the sample of sand selected to represent the separation of the screen. In other words, in present practice there are introduced two important variables, the one due to different materials, the other due to different manipulations of materials.

The fundamental assumption which is made in rating a sieve is that the sand grains are spheres. This, of course, is not true. Moreover, in some cases, the grains do not even approach spheres. Consequently experience indicates that there always are differences in the sizes of separations of a sieve depending upon the material selected to standardize and rate the sieve. Such differences frequently will amount to very much more than 0.005 mm. mentioned by Mr. Hazen to be "unmistakably apparent."

In order to obtain the accuracy mentioned by Mr. Hazen it is necessary that the sieves be rated with the materials which are to be analyzed.

Mr. Hazen refers to a comparative method of rating sieves which consists in determining the sizes of separations of a set of sieves from a determination of the percentages of separation of a sand which has been previously analyzed by a standard nest of sieves. This, of course, is true whether the size of opening or the size of separation of the sieve is used as a standard of measurement, and does not affect the point at issue.

It is a well known fact that it is not physically possible to manufacture wire cloth containing wires of absolutely uniform size and with absolutely uniform spaces between the wires. Consequently, it is argued that it is not practical or feasible to determine the size of separation by an examination of the cloth to determine the average size of openings. This criticism is undoubtedly true for the very fine wire cloth, but is not thought to be well taken for the comparatively coarse cloth containing 100 or less meshes per inch. It is possible today to obtain the coarser wire cloths woven with sufficient accuracy for all practical purposes.

Mr. Hazen argues that it is not a step in advance to change the standard of measurement from the size of separation to the size of opening because of the fact, as stated above, that the size of open-

ing is a variable, and because the larger openings determine the size of separation of a sieve. This point is well taken so far as it applies as a standard of measurement, but as above stated, it is the speaker's thought that even a greater variable is introduced by using the average diameter of the sand grains due to the fact that these grains seldom are round although they are necessarily assumed to be round in determining the size of separation of a sieve. This error of measurement is believed to be much greater than the error of measurement which might be assumed by determining and using the average diameter of the opening in the wire cloth.

In conclusion, it is believed that the matter may very well be handled in the same manner as has been used by the Bureau of Standards at Washington, D. C., in standardizing cement sieves. This bureau has recognized the fact that the standard 200 mesh sieves as required for cement testing are not uniform, and the bureau has coöperated with 80 laboratories throughout the country to determine the sieving value of the 200 mesh sieves, as used for cement testing. As the result of these experiences, the Bureau first drew up specifications defining the 200 mesh sieve in terms of the sizes and spacings of wires and permissible variations. Subsequent experience indicates, however, that the average opening in a sieve does not necessarily determine its sieving value, so that subsequently, the bureau revised its specifications to include a sieving value based upon certain standard material. At the present time, a standard of fineness has been adopted and standard samples of cement to be used for rating 200 mesh sieves are available at a cost of 25 cents to any one who may desire to check up his 200-mesh sieve.¹ The samples of cement are guaranteed to within 0.2 per cent on the fundamental standards of the bureau. This method of rating is in effect the same as the comparative method of rating sand sieves described by Mr. Hazen.

The speaker can see no reason why a similar method of obtaining standards may not be developed for use in connection with the coarser sieves used for the mechanical analyses of sands. It remains for the engineering profession to determine what sieves may properly be adopted as standards and to solicit the coöperation of the Bureau of Standards in this work. If such a set of standard sieves is adopted

¹ Reference: Technologic Paper No. 42—Bureau of Standards, Washington, D. C.

and if the sieves used by laboratories throughout the country are rated in this manner, it is a comparatively immaterial point whether the standard of measurement used is the size of opening or the size of separation. It is, however, very important that the method of obtaining satisfactory standards be available to every one interested.

Moreover, if such standard sieves are adopted, engineering specifications may be simplified to read in terms of these standards thus eliminating all ambiguity and indefiniteness of meaning.

The speaker is very well aware that Mr. Hazen, Mr. Fuller, and other engineers frequently prepare their specifications for filtering material to read in terms of sizes of grains avoiding the use of the terms "effective size" and "uniformity coefficient." However, it is undoubtedly true that the majority of rapid sand filter plants have been and are being constructed under specifications which contain these terms defining filtering material required. The same thing is true relative to filtering material which is purchased as required to maintain filter plants in operation after completion. Standard apparatus or method of analyses of filter sands certainly would be helpful in many cases in producing satisfactory material at the least cost.

It is somewhat remarkable that so little work has been done to determine the hydraulic values of filter sands and that the results of experiments obtained some 25 years ago have been almost universally accepted and adopted. The speaker is convinced that the term "effective size" as now used is of questionable value; in fact, it is his belief that the hydraulic value of a sand depends upon the average size of the particles and the uniformity of the material and not alone upon the size of the finest 10 per cent of the material.

However, it is not so much the thought to discuss the value of these terms at this time as to call to the attention of the engineering profession the necessity for adopting standard methods of analyzing sands used for all purposes. The necessity for such standards is universally recognized, and it is the speaker's opinion that it is a matter of a comparatively short time until such standards will be adopted.

STATE REGULATION OF MUNICIPALLY OWNED PLANTS¹

BY C. M. LARSON²

The real functions of a regulating body whether centralized as a state commission or localized in the common council or a local commission are very generally misunderstood. This is especially true if the plant under consideration is owned by a municipality. The proper regulation of any utility embraces two broad subjects: that of service and that of rates. The question of propriety of regulation of municipal plants will be much more readily understood if it be borne in mind at all times that the question of service to be rendered by a utility is of more importance than that of the rates charged. The primary purpose for which all utilities, private and municipal, are in existence is that of giving service to the public, the question of rates to be charged is of secondary importance. It must be insisted that the first duty of a utility is to furnish adequate service, even though a poorer service might be furnished at a lower rate.

It appears to be the general conception that the regulation of profits of a public utility is the prime function of a commission, and that, after the profits have been reduced to a reasonable amount, the services of the commission are no longer necessary. This conception is erroneous, but even if the question of profits alone were the only matter to be considered, the commission's duties are far from finished when the earnings of a utility plant are so adjusted that the total profits are no more than a just return upon the fair value of the property. The utility may be earning only a fair profit, or even less, and still the rates to certain individuals or class of individuals may be far from equitable. The problem of construction of schedules that will be equitable as between the various individuals and classes of consumers is a much more difficult matter than the regulation of total profits. To be equitable the schedules should be so arranged that each consumer is required to meet as nearly as possible his just

¹ Presented at the Annual Meeting of the Illinois Section of the American Water Works Association, Urbana, Illinois, March 10, 1915.

² Chief Engineer, Railroad Commission of Wisconsin, Madison, Wisconsin.

and proper share of the expenses of the utility. If the schedules are not so adjusted some consumers are actually paying for the service supplied to others. The removal of discrimination from the schedules of a utility plant is one of the hardest problems with which a regulating body has to deal. This applies as well to private plants as to municipal plants, but in the latter we often have more serious discrimination than in the former. Elimination of discrimination from schedules requires the most searching investigation by men of scientific training and practical knowledge of operating matters, and involves a recognition of the fact that certain costs are incurred as soon as a consumer is connected to the system, regardless of whether or not he makes use of the service, and that a minimum charge should be made to cover this, to which should be added a charge for the service actually rendered, this latter to be based upon the cost of rendering this service. Local managements do not always recognize the importance of these principles, and even if they do recognize them, they are often unwilling or unable to put them into effect. The question of equitable rates is in reality a very complicated one, and the employment of a person who is expert enough in rate matters to construct a schedule based upon a proper consideration of all items that should influence a decision in so important a matter is usually quite beyond the financial reach of small plants. Where is the small utility to turn for assistance at such times? Shall it maintain its so-called independence and continue to go on as before, obtaining indifferent success because nobody is able to offer something better, or because consumers or taxpayers are loath to make complaint of a plant in which they have an interest?

Let us see the results of such procedure. The commission in Wisconsin requires that each utility submit schedules of rates for approval. A great many so submitted are based on erroneous principles, as noted in the following case: In January, 1913, a municipality submitted the following schedule for water rates:

1000 gallons or less per month.....	\$0.60 per 1000 gallons
1000 to 2000 gallons per month.....	0.50 per 1000 gallons
2000 to 3000 gallons per month.....	0.40 per 1000 gallons
3000 to 4000 gallons per month.....	0.30 per 1000 gallons
Minimum charge \$7.50 per year	

This schedule appears to be based on equitable principles; apparently there is a fair minimum charge and the rates to the consumer

decrease as his consumption increases, but if these rates be plotted into a curve there at once appears a woeful amount of discrimination. If consumers "A," "B," and "C" use 2000, 2500, and 3325 gallons respectively, they each pay one dollar per month. If "A" who pays one dollar for 2000 gallons uses 2100 gallons, he falls into the second group and pays only 84 cents. Therefore by consuming 2100 gallons instead of 2000 gallons his bill becomes 84 cents instead of one dollar.

The above is simply an illustration recited as a type of what the smaller plants, whether private or municipal, must contend with largely because of inability to employ expert advice.

According to the annual returns received by the railroad commission from utilities in Wisconsin for the year ending June 30, 1914, we find that there are 196 electric plants privately owned and 72 electric plants owned by municipalities. All of those owned by municipalities with one exception are in towns, villages and cities with a population of less than 10,000. Reports from the water companies of this same date show that there are 26 plants owned by private parties and 163 by municipalities. No telephone companies are owned by municipalities in Wisconsin and municipal gas plants are of minor importance as only the small acetylene or gasoline plants are municipally owned. Thus it is seen that in the electric and water business there is a total of 222 privately owned and 235 municipally owned plants in the state. Several additional plants were built in the state during the year which received the attention of our inspectors but which did not make the regular annual report.

SERVICE

The public utilities commissions in several of the states, including Illinois and Wisconsin, have issued rules of service for gas and electric properties. Efforts have also been made to prescribe equitable service requirements with respect to the operation of water plants and tentative rules have been drawn in Wisconsin, but thus far no definite instructions have been issued. In all branches of utility service, however, high standards have been insisted upon, whether definite rules are published or not. Briefly these requirements are, in the electric business, a relatively constant voltage to be maintained at all times when required by the consumers, accuracy of meters, reasonable business methods and above all no dis-

crimination either in favor of or against any consumer. For water service, an adequate supply of good pure water, accuracy of meters, adequate provision for fire protection, and as in the electric business, reasonable business methods and no discrimination. Requirements for service in the gas business are based upon the same general consideration, with the addition of standards for heating value, limitations in pressure variations, and quality of the gas.

In order that the commission may be kept informed at all times respecting compliance with standard requirements in the various plants, the state has been divided into several districts, and an engineer placed in charge of each district whose duties include periodical visits to all plants, for the purpose of checking up service in each, and also for the purpose of offering such advice as possible where this seems necessary.

During the year ending June 30, 1914, these engineers made 209 inspections of 170 of the privately owned electric plants and 94 inspections of the 76 municipally owned electric plants, making an average of about 1.2 inspections per plant. No regular service inspections of water plants are carried on in Wisconsin. In the investigations made by our inspectors, not only of complaints but of routine service matters, it is found that the rules and regulations laid down by the commission are being violated continually by municipal as well as by private utilities and it is necessary to follow up these inspections from time to time in order to impress upon the operators the importance of rendering such service that full compliance with the rules will result. These violations are most often in the nature of excessive voltage or pressure variation, low heating value of gas, failure to test meters within the proper time, etc.

The following brief review of inspection records of a typical small municipal electric plant gives an idea of the developments from the first inspection to the present time:

This municipal plant was first inspected in March, 1909. Two single phase generators supplied the service to 180 consumers.

An inspection in December, 1909, showed that the utility was not fully complying with the meter requirements, although satisfactory voltage regulation was being maintained.

An inspection in June, 1910, showed that the meters had been tested, as required, but that there was excessive variation in three of the six localities where records were taken. Several interruptions in service had occurred on account of the same trouble. Installation meter tests were not being made, as required.

An inspection in September, 1910, showed three of the four voltage records outside of the allowable limits.

An inspection in October, 1911, showed the voltage regulation to be unsatisfactory, the meters had been neglected and the master meter was found to be in unsatisfactory condition for use.

An inspection in June, 1912, showed that the voltage variation was even worse than that formerly reported and that meter testing rules were still receiving practically no attention. There have been several changes in management of this plant, but in June, 1912, the new manager reported about one-half of the meters tested.

In October, 1912, substantially the same conditions prevailed.

In January, 1913, a follow-up inspection was made which showed that no meter testing progress had been made. The superintendent gave as his reason that he had too many duties in connection with the plant operation to take care of these matters. After taking this up with the mayor another inspection was made in April, 1913, which showed that the majority of the meters had been tested and that there were still many interruptions in service. No voltage records were taken at this time. All meters were reported tested in June, 1913.

An inspection in September, 1913, showed that they are in need of additional station capacity in order to properly take care of the winter load.

In November, 1913, it was found that a new engine was being installed.

In March, 1914, an automatic voltage regulator and other equipment were ordered.

An inspection in March, 1914, showed satisfactory regulation in some sections of the system, although there was excessive variation in others. About 40 per cent of the meters were due for test.

An inspection in January, 1915, showed that some 90 meters were due for test out of a total of 280. Interruptions in service had been practically eliminated and the voltage regulation substantially improved, although still outside the requirements in some localities.

On one occasion an inspector reached a municipal plant within a few days after its one engine had broken down and the lighting business had been entirely discontinued. Upon inquiry he discovered that it was the intention of the village to keep its plant closed down until a new engine could be purchased and installed. He immediately made inquiries in the neighborhood, found a traction engine that was available, had this installed and electric service supplied the village within 24 hours. This traction engine carried the load successfully, though of course not very satisfactorily with respect to voltage regulation, until the new engine was purchased and the service again placed on a substantial basis.

In another instance complaint was brought before the commission of the condition of the water supplied by a municipal water plant in

a large city. After investigation the commission decided that it was necessary to seek an entirely new supply. The water had been taken from a river and pumped into the mains without filtration. The commission made extensive investigations and discovered that a very satisfactory supply of water could be obtained from wells driven on some vacant land within a short distance of the city. The city was required to purchase this land, drive the wells and install a new pumping system with the result that it now has a very good sanitary supply of water.

As an illustration of the variety of subjects which must be dealt with by each plant the following brief summary is submitted of the work carried on by one of the district engineers during one month late last year:

The inspector visited Mineral Point where a routine electric service inspection was made, including the taking of four voltage records by means of a recording instrument installed in each of two localities. A complete inspection of the meter and station records for the past year and a half was made and three persons were interviewed regarding electric service matters. A detailed report was made of considerable new electrical construction work. While in Mineral Point two telephone utilities were inspected, data collected regarding the equipment and operating conditions of each for the state telephone directory, as well as a report regarding the compliance of each company with the various rules of telephone service. Data were also collected for the water works directory.

While the recording instruments were still connected at Mineral Point, the inspector checked up the service conditions at Linden which included the meter operating records of the electric utility, the checking up of telephone service conditions and the collection of data for the water works directory. While in Linden the inspector received an informal complaint regarding the routing of telephone toll messages and controversy between the disputing companies was partly adjusted by the inspector and the questions which he was unable to settle in the field were reported to the commission for further attention.

Dodgeville was next visited where routine electric and telephone service inspections were made and the data for the water works directory collected.

A formal investigation regarding the service of the Leeds Farmers' Telephone Company necessitated that the inspector meet with the stockholders and directors of this company at an inland town 8 or 10 miles from the railroad at which time several hours were spent in discussing in open meeting the various solutions of the difficulty pending to determine as far as possible which of the several possible solutions would best suit the subscribers. After this meeting the inspector made definite recommendations regarding the telephone engineering features involved. This matter was handled on a Saturday and was not far from headquarters.

During the following week routine electric, telephone and water works matters were covered for Hazel Green, Benton, Cuba City and Shullsburg.

It was also necessary for the inspector to visit Galena, Illinois, where the main offices and plant of the Interstate Light & Power Company are located. This utility supplies the service in Platteville, Shullsburg, and to many mines in Wisconsin, and sells current to the municipalities of Hazel Green, Benton and Cuba City that supply service within their own limits.

On the following Monday the inspector returned to his routine work in the southwestern part of the district, visiting Platteville where one routine electric and two telephone service inspections were made, including the various phases of the work handled above. Eight voltage records were taken in Platteville and the records summarized for the past 10 months. Data for the water works directory were also collected in this city. The inspector also investigated the origin of two fires which were caused by high potential wires coming in contact with secondaries entering buildings. This was made upon informal complaint by the president of the Business Men's League, who requested the inspector to make the investigation stating that he had just sent a letter to the commission requesting that this be done.

The inspector next visited Lancaster and checked up the routine matters in connection with one electric and two telephone utilities. This involved the description of the equipment and practice of seven telephone centrals; also report regarding construction of transmission lines by the Lancaster utility. Water works directory data were also collected.

Fennimore was then visited where the routine work was carried on in connection with one electric and three telephone utilities. Material for the water works directory was collected and local conditions regarding a formal complaint on electric service, rates, etc., were investigated. A routine inspection was made at Belmont covering electric and telephone utilities, and Dodgeville was again visited on the way to headquarters to check up the complaint of a consumer alleging inadequate and interrupted power service. This complaint had not reached the commission in time to be investigated at the earlier visit to Dodgeville.

During the following week two days were spent at Muscoda in connection with the routine electric and telephone inspections. Investigations were also made in connection with a formal telephone service complaint after which recommendations were made regarding the decision in the case. Several meters were tested to acquaint the local superintendent with the commission's method of testing and to investigate an informal complaint regarding the accuracy of a certain meter adjustment for assumed over-charge of a meter which the inspector found to be accurate. Another informal matter handled in Muscoda was in connection with an alleged discriminatory rate charged the railroad company for lighting the depot. In addition to the above matters handled in the field, the inspector spent two days on office work writing up reports and looking over records of previous inspections.

In all cases a part of the engineers' work consists of investigating as to the manner in which each utility is complying with the various rules, together with suggestions and instructions respecting them as well as respecting efficiency, safety, etc.

RATES

The principle now appears to be pretty well established that rates should be based primarily upon the cost of service. A thorough understanding of the operating conditions of a plant must therefore be obtained before any determination of the proper charges for service to a consumer can be made. Before reasonable cost can be ascertained it is necessary that the investigating body have accurate detailed operating cost records of the plant under consideration, comparative cost records of plants operating under similar conditions, and a thorough understanding of the local conditions surrounding each plant.

The importance of these considerations was early recognized and shortly after the public utilities law became effective in 1907, the Railroad Commission of Wisconsin ordered all utilities to keep accounts according to certain prescribed forms. The forms required vary with the class of utility and with the size of the community served. In general, class A reports are required from cities of 10,000 population or over; class B reports from cities with a population of from 3000 to 5000; class C reports from cities with a population of 1800 to 3000; class D reports from cities and villages with a population of 700 to 1800; and a report called the "condensed" report for utilities in towns and villages having a population less than 700.

The following is quoted from an unpublished report recently made by the statistical department of the railroad commission. It sums up briefly the purposes for which the uniform classification was inaugurated:

The uniform classification of accounts prescribed for the utilities of the state is designed particularly to meet the needs for rate making purposes. The main object of this system of accounts is to so group the operating expenses that the cost for different consumers and classes of consumers can be determined. Each class of service incurs certain expenses. The requirement in the accounting procedure, therefore, is to segregate and apportion the operating expenses as far as practicable among the classes served. Certain expenses may be charged directly to the service for which they are incurred, and other items which cannot be so distributed because they are common to two or more services are placed in classifications by themselves so that when the question affecting rates arises they can be distributed over the respective classes by the rate fixing body, according to known facts and established principles. Unless the accounts of the utility under consideration have been kept in accordance with the principles of cost accounting, the cost of service for the respective consumers cannot be determined. Any other basis for the determination thereof would result merely in individual opinion and estimates.

A great deal of objection is raised by municipalities in Wisconsin against those requirements for the keeping of uniform records, due largely to a lack of appreciation of their value for the purposes for which they are intended. Little difficulty has been experienced by the commission in persuading the private utilities to keep such records properly, but some of the municipalities have been hard to convince. Several years ago one city in Wisconsin, having a population of about 17,000 people, took over its water plant from a private concern as permitted under the provisions of the public utilities law. The commission has ever since been trying to induce the city to keep accurate operating records as well as construction costs. Recently a complaint on rates was made against the city; the engineers visited the place to obtain records of construction and cost and found the book-keeping in very poor condition. All items of expense of the city, including water works construction, operation, etc., were on consecutively numbered vouchers. In order to determine what had been spent for construction and operation of the water plant it was necessary for the engineer to look through every voucher passed by the city in the years since the plant was taken over. The cities do not appear to comprehend the fact that accurate records of the financial transactions of the utility are necessary as a basis for the determination of equitable rate schedules.

If, however, it be conceded that consumers are receiving equitable treatment only when the schedules are so constructed that each is required to meet as nearly as possible his proper share of the expenses of the utility, then the necessity for keeping accurate operating records is proved, for in no other way can these results be obtained. Several instances have occurred in Wisconsin in which the railroad commission has found it impossible to make rulings on account of lack of operating records, and it has been found necessary to postpone the decisions until at least one year's records could be obtained.

Quoting from the decision of the commission in the case of the Troy and Honey Creek Telephone Company for authority to increase rates, W. R. C. R., Volume 6, page 555:

Until the utility keeps the cost of renewals, replacements, and new construction separate from operating expenses, it will be impossible to determine the exact needs of the company in the way of revenue. . . . It is quite possible that the application therein is reasonable and that it should be granted. Just what the real situation is in this respect, however, we have not been able to fully determine, owing to the condition of the records and the reports of the business of the plant that have been submitted to us. If the

petitioner will comply with the Utilities Law and keep its records as provided therein, or so as to disclose the condition of its business. . . . this Commission will be ready to reopen this case and to endeavor to the best of its ability to reach a fair and equitable decision therein. Until these steps have been taken by the petitioner, we are not in a position to safely pass upon the issues involved, and the proceedings in this matter are therefore, for the present, dismissed.

There have also been before the commission many other cases of a similar nature which it was found impossible to handle in a satisfactory manner because of lack of proper operating statistics. This question of proper operating data is in a sense independent of the question of state control, but without some centralized regulating body requiring these reports there is very little reason to think that either municipal or private utilities will keep records in such form as to be of use for these purposes.

The reports received by the Railroad Commission of Wisconsin from various utilities for the year ending June 30, 1914, have been divided into three classes: good reports, fair reports, and poor reports. These are tabulated below for electric plants and for water plants, separating between private and municipally owned properties and further separating as between the various classes of utility according to the size of the city served.

Number of electric plants in Wisconsin making good, fair and poor reports to the railroad commission on June 30, 1914

CLASS	PRIVATE				MUNICIPAL			
	G	F	P	Total	G	F	P	Total
A.....	20	6	4	30	*			
B.....	19	16	5	40	5	3	9	17
C.....	12	9	3	24	5	5	2	12
D.....	22	14	7	43	8	7	10	25
Condensed	19	26	14	59	3	10	5	18
Total.....	92	71	33	196	21	25	26	72
Per cent.....	47	36	17	100	29	35	36	100

* At this time there were no class A municipal electric plants in Wisconsin.

Number of water plants in Wisconsin making good, fair and poor reports to the railroad commission of June 20, 1914

CLASS	PRIVATE				MUNICIPAL			
	G	F	P	Total	G	F	P	Total
A.....	7	1	1	9	5	6	2	13
B.....	3	1	4	8	8	9	20	37
C.....	2	0	0	2	8	8	8	24
D.....	1	1	1	3	7	22	22	51
Condensed	2	1	1	4	15	14	9	38
Total.....	15	4	7	26	43	59	61	163
Per cent.....	58	15	27	100	27	36	37	100

In general, this information may be summed up as follows: of the 196 electric plants privately owned 47 per cent made good reports, 36 per cent made fair reports, and 17 per cent made poor reports. Of the 72 electric plants municipally owned 29 per cent made good reports, 35 per cent made fair reports, and 36 per cent made poor reports. Of the 26 water plants privately owned 58 per cent made good reports, 15 per cent made fair reports, and 27 per cent made poor reports. Of the 163 water plants municipally owned 27 per cent made good reports, 36 per cent made fair reports, and 37 per cent made poor reports.

The tables given below show the financial data with respect to the municipal plants both electric and water which make the reports referred to in the above table.

Summary of financial data of municipal electric utilities in fourth class cities and villages June 30, 1914*

	PROPERTY AND PLANT	OPERATING REVENUES	OPERATING EXPENSES**
Good reports.....	\$679,793	\$225,295	\$150,637
Fair reports.....	548,362	182,456	129,934
Poor reports.....	416,999	154,830	106,284
Total.....	\$1,645,154	\$562,581	\$286,853

* 10 utilities are omitted because of incomplete reports or unavailable data.

** Excluding interest, depreciation and taxes.

Summary of financial data of municipal water utilities in fourth class cities and villages June 30, 1914*

	PROPERTY AND PLANT	OPERATING REVENUES	OPERATING EXPENSES
Good reports.....	\$1,354,879	\$147,881	\$86,319
Fair reports.....	2,109,048	238,797	158,062
Poor reports.....	1,481,500	172,495	104,584
Total.....	\$4,945,427	\$559,173	\$348,965

* 25 cities are omitted because of incomplete reports or unavailable data.

Summary of financial data of municipal water utilities in cities of 10,000 population or over June 30, 1914

	PROPERTY AND PLANT	OPERATING REVENUES	OPERATING EXPENSES*
**Good reports.....	\$9,652,303	\$1,171,884	\$357,367
Fair reports.....	2,342,542	202,969	90,764
Poor reports.....	726,931	96,570	41,261
Total.....	\$12,721,776	\$1,471,423	\$489,392

* Excludes interest, depreciation and taxes.

** Includes Milwaukee, the values for which are more than three-fourths of the total.

From the above tables the following facts may be gleaned: for the municipal electric utilities making these reports 60 per cent of the operating revenues are in plants from which unsatisfactory reports are received.

In the municipal water utilities in fourth class cities and villages 74 per cent of operating revenues are in plants from which unsatisfactory reports are received; and in the municipal water utilities in cities of 10,000 population and over, 21 per cent of operating expenses are in plants from which unsatisfactory reports are received. This latter per cent would be considerably higher were it not for the fact that the city of Milwaukee makes a good report and its values are some two-thirds of the total values in the entire group.

Since both fair and poor reports indicate a lack of knowledge of what is really being accomplished in operating matters, a further summary would be as follows: in the privately owned electric plants in Wisconsin 53 per cent of the reports were unsatisfactory; in the municipal electric plants 71 per cent were unsatisfactory; in the privately owned water plants 42 per cent were unsatisfactory and in the municipal water plants 73 per cent were unsatisfactory.

In spite of the unsatisfactory condition of the reports received there is shown a great advance over the records kept before the commission prescribed definite forms of accounts. Recently the commission's accounting department has been giving a great deal of assistance to municipalities as well as private owners of utilities for the purpose of starting them out on a proper accounting basis. It is found that when not required to do so by the commission, municipal utilities seldom keep records in proper shape for adjustment of rates. Construction costs are confused with operating expenses; in many cases no distinction is made between repairs and replacements. Many times the records of the utilities are not separated from those of the general business of the city as was illustrated in the case above cited. Not only is it impossible from such records to make a fair determination of the cost of the different classes of service, but even the total cost of the service cannot be obtained. Such records must be kept properly whether rates are to be controlled by the central commission or by the municipality itself.

It is readily conceivable that a schedule of rates may be free from discrimination as to individual consumers, as well as to classes of consumers and the total profits may not be excessive, but still the consumers as a whole may be paying more than they properly ought to pay, because of inefficient operation of the plant. The question in this form applies as much to municipal plants as to privately owned plants. It is important to know that operation is efficient, and in order to determine this question it is necessary to have records of plants other than the particular one under consideration. With a system of local municipal control there is but one method of obtaining this information. Each municipal utility will be put to the expense of making such an investigation of the records of other plants as may be required to determine this matter. This investigation will necessarily have to be made by some person properly equipped to make such a study and few, if any, of the smaller municipal utilities can afford such an investigation. Even the possibility of such an investigation presupposes that the individual plant records will be properly kept, which past experience shows is not the case. Furthermore, even though the individual utilities may keep their records in such form as to determine this matter of proper expense in a satisfactory manner, still, unless there is distinct uniformity in the accounting methods, it will be difficult to make the necessary comparisons. Under supervision of the Railroad Commission of Wisconsin

this question of uniform accounting is insisted upon and is being obtained.

In order to illustrate another important use to be made of operating statistics there is given the following table showing the total operating expenses in dollars per million gallons pumped for Class A municipal water utilities, taken from the annual reports for the fiscal year ending June 30, 1912:

Municipal water utilities—class A

Detailed and total operating expenses in dollars per million gallons pumped for year ending June 30, 1912

LOCATION OF COMPANY	MILLION GALLONS PUMPED	TOTAL PUMPING	TOTAL DISTRIBUTION	TOTAL COMMERCIAL	TOTAL GENERAL	TOTAL UNDISTRIBUTED	TOTAL OPERATING EXPENSES
Appleton.....	513	\$16.58	\$2.85	\$0.62	\$1.75	\$0.75	\$22.15
Eau Claire.....	730	7.80	5.18	2.12	1.31	0.55	16.96
Kenosha.....	1,161	11.50	3.89	1.21	1.23	0.17	18.00
La Crosse.....	1,025	15.91	5.05	0.39	0.84	0.34	22.53
Madison.....	688	38.21	6.86	4.50	2.14	0.61	52.32
Manitowoc.....	332	19.51	5.90	0.38	1.88	0.77	28.44
Milwaukee.....	17,024	6.69	3.66	3.32	1.34	0.90	15.91
Sheboygan.....	1,121	11.52	2.62	0.33	2.54	1.17	18.18
Watertown.....	304	25.25	6.99	2.23	4.35	0.86	37.45
Waukesha.....	264	54.59	27.47	0.33	7.38		91.67
Wausau.....	841	12.64	2.07		1.18	0.38	16.60
Average.....	1,495	20.94	5.53	1.85	6.05	0.89	35.32

The above table shows the total cost per million gallons pumped as well as the various items which compose this total, such as cost of pumping, distribution, etc. This has been determined upon a uniform basis and shows the particular plants which are operating at a cost far above the average. In one case the total cost per million gallons pumped is \$91.67 and in another \$52.32. The normal cost exclusive of these two plants is approximately \$25 per million gallons pumped. These figures are of course not conclusive evidence that the two plants mentioned are being inefficiently operated, but it opens a line for careful investigation of these plants. Add to the above a definite knowledge of local conditions surrounding each situation and it is then possible to make a proper decision in each case. Such methods of keeping records permit an investigation not only of the

total actual cost but of each particular item of cost, which thus permits the matter to be attacked in the necessary detail. In the accounting required by the commission the accounts are still further subdivided in order to assist in detecting the various items which go to make up the particular cost in each class.

In a recent investigation by the commission with respect to the rate in a gas plant, the accounting showed that, by comparison with results obtained with other plants, this utility was producing some 10 per cent less gas per pound of coal than the normal and that the losses in distribution were almost twice the normal. It was also found that the maintenance expenses were some six cents *more* per thousand cubic foot of sales than the normal as shown by other plants. These facts were taken up with the utility management who admitted the inefficiency and acknowledged that these matters should be taken into account in the fixing of rates.

In another case in which water rates were under investigation comparisons with other utilities showed that the cost of fuel used for pumping was considerably above normal. In that way it was determined that a reduction of about 40 per cent should be made. As a result this reduction was actually made in computing rates. Since that time the expenses for fuel in the operation of this plant have been within 5 per cent of the amount determined upon by the commission.

These illustrations of course are applicable to municipal as well as to privately owned utilities and are cited for the purpose of emphasizing the necessity of accurate accounting methods.

The commission has had before it many cases involving rates and service of municipal plants. An investigation of the various reports and files of the commission shows that these complaints are on a variety of subjects, such for instance as the following: excessive and unwarranted water rates, inadequate commercial service, unsatisfactory water resulting from failure to flush out mains, sand and dirt in the mains, unsanitary supply, inadequate supply, lack of pressure for fire protection, entire discontinuance of service, discrimination between metered and flat rate customers, unjustifiable rates, application for increases in rates, application for equalization of rates, application for adjustment of individual rates, installation of meters and proper manner of paying for same, refusal to permit use of certain types of meters, inequitable distribution of rates, refusal to furnish electric and water rates, refusal to extend water mains and electric wires, classification of certain services, complaint against

council for changes in rates, excessive charges due to leakages, application for valuation for municipal purchase.

This list of types of complaint shows the great variety of subjects which the commission is required to deal with in connection with municipal plants, where the question of total profits is not an issue. In view of this, where is the individual consumer to find redress if there is no central disinterested body in control? If redress were possible with local control, why should not these matters have received the necessary consideration without compelling the individual to go to the commission for satisfaction? Is it likely that the local authorities will be more anxious to satisfy the complainant if there is no opportunity for him to appeal than when it is a known fact that he can lay his case before the higher authority?

Even when municipalities undertake the making of schedules with the best of intentions they are in general not in any position, because of lack of ability or finances, to attack the problem in a proper manner, and, when their actions are controlled or affected by political issues, the question of equitable rates is too often subordinated to political demands. In many cases the operation of the plants is used to furnish capital for city politics and under such circumstances it is difficult to conceive of fair rate schedules being put into effect by municipalities when the matter is not controlled by a central body. Experience in Wisconsin before the utilities law became effective, which is probably duplicated in all other states, has been that in many cities and villages under municipal control some individuals are actually given water, gas, or electric service for years without contributing one cent and often without even a record that a service connection had been made. The other consumers are necessarily called upon to pay increased bills resulting from such discrimination.

In general each utility, whether municipal or privately owned, is supplying two distinct types of service. First, public service such as protection against fire, street lighting, water and lighting for public buildings, etc. Second, service to private consumers such as general lighting, power and water service. In other words, the two distinct types of service are, first, those for which payment should be made by taxpayers through the medium of the city taxing department, and second, those for which each private consumer should pay his fair share direct to the department. In all investigations relative to rates the first consideration should be a fair division between the

property used for public purposes and that used for supplying private consumers. The engineers of the Railroad Commission of Wisconsin have made very careful separations of these values in all instances, and the accounts are required to be kept in such manner that operating expenses may likewise be divided between these two principal accounts. It is often a difficult matter to induce municipalities to permit the water and light department to render bills against the city for the proper amounts to cover the share of the expenses which are properly chargeable to the taxpayers, and it is more difficult still to secure the actual payment of these amounts, yet for every dollar thus retained the consumers have to pay a corresponding amount in addition to the cost of their own service, which amount should in justice have been paid by the taxpayers. Taxes are unpopular and unless compelled to do otherwise there is a strong tendency on the part of municipal authorities to keep taxes down at the expense of the private consumers.

Schedules submitted by municipal plants for approval by the railroad commission often show the following inequalities: in some the city pays nothing for service and the general users bear all of this cost. This results in discrimination in favor of taxpayers. In some cases the city pays a part of the cost of public service but not a sufficient amount. This again results in discrimination in favor of the taxpayers. This condition exists where hydrant rental or street lighting allowances are too low or where no charge is made against the city for lighting and water service to schools and other public buildings. In some cases the rates for general service are so low that they do not cover the fair share which the consumers should bear, the remainder being made up by taxation. This results in discrimination in favor of the consumers and against the taxpayers. These points emphasize the necessity of a careful study of the two phases of the problem in order that each may receive just consideration and discrimination be avoided.

As a further illustration of the above remarks we find in one of the commission's decisions relating to a municipal electric light and water plant the following:

The investigation has shown that while the electric department is self-sustaining the water department has failed to earn a sufficient revenue to meet its legitimate expenses. . . . That while a reduction in rates for electric service can be offered, the rates should be adjusted so as to more equitably distribute the burden of expenses; that the charge for street lighting should

be increased in order that this branch of the service bear its just share of the total cost of operation; that the water rates should be adjusted so as to better meet the conditions now existing and which in the near future will exist. That the city should bear a larger burden of expenses due to the larger proportion of the system made necessary for fire protection and other public uses. W. R. C. R., vol. 5, p. 5.

After having made a proper division between expenses chargeable against the public and those chargeable against the private consumer, then further subdivisions are needed to determine the fair division of cost between different classes of consumers, such as users of electric light as compared with those using electric power; users of water for domestic purposes only as compared with those using water for commercial and industrial purposes. Often these consumers are placed either on a flat rate or a uniform meter rate with the result that there are usually discriminations affecting the different interests.

One of the difficult features which must receive consideration whether the rate schedules are being prepared by local management or by a central body has not yet been touched upon. An electric plant must be of such capacity that it can at any time and upon a moment's notice be called upon to supply the maximum demand which may be put upon it. In this it differs from a gas plant or a water works plant in both of which the product can be stored. Electrical energy can be stored only to a very limited extent and even such storage requires expensive equipment. The question of fair rates between consumers, some of which use this electric power only during peak periods, others of which use it only during off-peak periods, and others which use it during all periods of the day, is one with which the average plant operator is unable to cope and unless schedules are made or supervised by trained and experienced authority, discriminations are certain to result due to the above mentioned causes. Furthermore, each particular case is a problem in itself and though the same principle may be applied to all, each must receive separate consideration.

It is often easy for a plant operator to discover various discriminations, but in general it is beyond the ability of the average manager or local commission to so construct a schedule that these will be eliminated. This inability is emphasized in many cases brought before the commission. The following is quoted from some recent decisions of the commission, as samples of a great many such cases brought up for adjustment:

In Re Application of the Cumberland Municipal Electric Light Plant for Authority to Increase Rates. "The applicant in this case desired to increase certain of its present rates for electric current, on the ground that these rates were inadequate and did not cover the cost of furnishing the service involved. Upon hearing and investigation it was found that the applicant's rate schedule was not properly adjusted and that certain classes of consumers paid less than their just share of the cost of operating the plant. Because of these facts the Commission endeavored to compute more equitable schedules of rates, and has authorized the applicant to put these rates into effect." 4 W. R. C. R. 214.

In Re Application of Stoughton Municipal Electric Light System for Authority to Increase Rates. "The applicant in this case stated in its petition that it desired to make such changes in its rate schedules as to enable it to more fully extend its business. At the hearing in this matter it was shown that the present schedules were not, on the whole, so adjusted as to meet local requirements. These facts were substantiated by the further investigation into the situation which was made by this Commission. For these reasons the applicant was authorized to readjust its rate schedules on the basis outlined in the order in this case." 3 W. R. C. R. 484.

The authorities are coming more and more to realize the necessity for scientific investigation of methods of rate making with respect to the cost of service principle and many cases are being laid before the railroad commission for determination. The following quotations are samples of the many cases of this nature being voluntarily brought before the commission by the city and village officers themselves.

Board of Water Commissioners of Fond du Lac. the Railroad Commission has been called upon to recommend not only rates for service, but also to recommend an entire set of rules and regulations governing the relations between the plant and its consumers.

Baraboo City Water Works. This is a request made by the water works commission of the city of Baraboo that the Railroad Commission investigate the financial and operating condition of the Baraboo Municipal Water Works Plant and recommend a fair and equitable apportionment of the total expenses of said plant between the *public or city* and *private or domestic* consumers, and also to make such further recommendations as regards the *rate schedule* in general as may appear just and reasonable in view of the conditions.

Evansville Municipal Electric Light Plant. "This matter is an investigation on motion of the Commission of the rates, rules and regulations of the municipal electric and water utilities of Evansville, Wisconsin. The investigation arises from a series of requests from the city's officials for assistance in revising and adjusting the rates and practices of its utilities."

Following is a list giving some of the lines in which the Railroad Commission of Wisconsin is voluntarily assisting municipalities with a view of improving standards of service, and insuring equitable rates:

Establishment of proper accounting procedure, calculation of proper rate schedules, proper methods of recording meter test records, calibration of necessary testing apparatus, assistance in regulation of voltage and other features of the service, assistance in drawing contracts for construction of electrical and water plants, assistance in determining upon satisfactory water supply, investigation of water power sites for municipal plants, valuation of property for purposes of accounting, valuation of property for municipal purchase, many other consulting engineering matters on a variety of subjects connected with the construction and operation of water, gas and electric properties.

During the first few years of the operation of the public utilities law in Wisconsin the various utilities found difficulty in complying with the uniform accounting system required by the railroad commission. Small utilities were unable to pay the amounts demanded by private accountants for doing the work and these accountants did not always adhere strictly to the commission's classification. As this latter is an essential feature for the purpose of rate making, the commission adopted the system of supplying accounting assistance to utilities. This is done by the commission's own accountants and the utilities are required only to pay the actual cost thereon. Many municipalities are taking advantage of this opportunity and the commission is installing accounting systems as rapidly as its accountants can carry out the work.

No doubt one of the best means within reach of operators for keeping themselves informed in the utility business is to become identified with national associations organized for the promotion of the interests of those connected with utility business.

In order to obtain an idea as to what extent those interested in plant operation, especially those connected with municipal plants, are availing themselves of such opportunities to familiarize themselves with latest practices, search was made of the 1914 membership list of the American Water Works Association for the names of persons identified with various plants, municipal and private, in Wisconsin. The results of this investigation show that of the 26 privately owned water plants in Wisconsin 6 are represented in the active membership and none in the corporate membership. Of the 163 municipal water plants in Wisconsin 9 are represented in the active membership and one in the corporate membership.

A similar investigation of the membership of the New England

Water Works Association reveals the fact that of the six members residing in Wisconsin, one represents a private plant, and none represent municipal plants.

The membership list of the Wisconsin Electrical Association shows 5 individual members and 4 company or commission members representing the 72 or more municipal electric plants in the state.

The exceedingly small number of members of the two national water works associations representing municipal plants in Wisconsin, being only 9 for the 163 plants, and the correspondingly small number belonging to the electrical association indicate that municipal officers are very slow in taking advantage of the means readily at hand for keeping themselves informed upon important matters over which they have control and for which they should feel a deep concern.

No doubt the short tenure of office which is so general in municipal affairs is largely responsible for this condition. But whatever the reason, it is a fact that has a decided bearing upon regulation of utilities by local boards. It is very probable that this short tenure of office is one reason for inefficiency in municipal plant operation. All too often a change in the personnel of the city officers means a change in the management of the plants. Again, each administration is loath to assume the responsibility of burdening the city or village with new machinery or equipment, the result being that obsolete or inadequate types are very often retained in municipal plants long after their usefulness is gone, a fact that would be recognized and remedied much earlier in a privately owned plant.

These remarks are not intended as arguments against the municipal ownership of public utilities. They are intended to point out the fundamental difficulties certain to be encountered by municipalities in attempting to obtain high standards of service and fair rate schedules for their own utilities. In very few instances are the municipalities financially able to employ the necessary expert advice to build up proper schedules or recommend proper standards of service. Furthermore, without uniform accounting systems, what basis could even an expert employ? It is certain that uniform accounting systems will not be installed unless a central board or commission prescribes such systems and has authority to see that the accounts are properly kept.

A state commission, by the employment of a very few experts, can be in position to install and supervise proper accounting methods

at almost negligible cost to the hundreds of utilities in the state. By means of their experience and training, supplemented by the statistics thus obtained, these experts are in position to recommend advisedly on the subjects of proper rates. Engineer inspectors who visit all plants and study methods of operation under all varying conditions with respect to economy and efficiency are surely better able to advise with respect to standards of service and operating economies than are local boards or managers who seldom if ever observe conditions outside of their own neighborhoods, and whose terms of office are often so limited that they are no more than partially acquainted with their own local problems than new officers supplant them, who in turn have the same problems to master. Under such circumstances it is no reflection upon these local boards and managers to say that the problems are quite beyond them. The conditions are not within their control. But here stands an ever ready agency supplied by the state and prepared to give just such advice and assistance as are necessary to permit these managers to meet their problems in an efficient and inexpensive manner. Why should they not avail themselves of it? One of the very disheartening features of our experience in trying to maintain high standards of service, especially in the electrical field in Wisconsin, is the distinct deterioration often noticeable at once upon a change of management. After years of patient labor building up a municipal plant to the point where conditions are satisfactory, the inspector returns after a few months absence to find a new man in charge who is entirely ignorant of all that has gone before. A large part of the work has to be done over again in the same painstaking manner. The effect of these lapses is discouraging, but they serve to emphasize most emphatically the great advantage of having at hand means of placing the service again on its high plane, and are sharp reminders of what might be expected of the future of the service if no such authority existed.

There appears to be a well established conviction that a central commission is needed to regulate service and rates of private utilities. Conceding this, and in view of what has been shown above, is this not itself a strong argument for regulation of municipal properties also by a centralized body?

There is no doubt that the service standards and accounting methods prescribed and insisted upon by the railroad commission throw a burden upon municipal plant operators that could be avoided to a large extent if these managers were left to their own devices,

but the fact should always be borne in mind that these standards and methods are installed primarily for the benefit of the consumers.

Village and city boards and councils are in position to make their protests heard and felt through legislation, but it is the writer's firm belief that if the consumers who are the principal owners of municipal plants and the ones who benefit most by proper rate and service regulation had a thorough understanding of the benefits to be derived from state regulation and could balance these considerations against all the disadvantages, they would almost unanimously demand state regulation with its relief from inefficient and often indifferent control by local boards or commissions.

SOME ECONOMIC ASPECTS OF WATER WORKS VALUATION

BY RALPH E. HEILMAN¹

The valuation of utility properties for rate making purposes has become an important problem in recent years. It will no doubt soon prove to be an important problem for all the privately owned water plants in Illinois, for the recent act creating the Public Utilities Commission places all such properties under the control of that commission. This act apparently gives to the commission the power to regulate, change or re-adjust the water rates at any time it may choose to do so in spite of the fact that many water companies are operating under franchises previously granted by municipalities, which give the right to make a certain charge until the expiration of the franchise period. This act apparently repeals and annuls all such outstanding franchises, and so the commission holds. Therefore, the question of valuation becomes of importance since the commission, in the opinion of the courts, must rest its rates upon the value of the property.

Valuation of water works is largely an engineering problem. Nevertheless, there are some very important aspects which present themselves concerning which the economist feels that he has something to say. There are several such economic questions, as for example, the allowance to be made in the valuation for franchise, good will, going concern, developmental expense and early losses. In the limited time at his disposal the writer will be able to discuss only one, namely, the proper allowance for developmental expenses and early losses.

A water works plant, like other businesses, often does not do a paying business during the first few years of operation. Business must be built up, individuals must be impressed with the superiority of the service over the use of wells, patronage must become established before the company really begins to earn a profit or fair return. Should not the expenditures thus incurred be included in

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the valuation of the plant for rate making? If the corporations are to receive a return which would be only sufficient to attract capital under present conditions, what is to be done regarding the deficit or dearth of adequate returns during the early years of the company's history? Are these not a part of the investment necessary to establish the business?

Four methods of dealing with this problem in utility rate cases have been adopted. (1) Refusal to allow anything for this purpose. Both the Nevada and Nebraska commissions have taken this position. This position is essentially unsound. It is evident that unless such losses are in some way made up to the companies, private capital for utility enterprises will not continue to be forthcoming. (2) The Wisconsin method, which is to add early deficits and developmental losses to the valuation of the plant. Such losses, therefore, become assets, upon which the consumers are to pay a return permanently. (3) The New York First District commission's plan, which is to permit the company to charge in later years a rate sufficient to offset the deficiencies below a fair rate in the early years. (4) The New Jersey method, which is to add all expenditures to develop patronage to the valuation of the property.

The Wisconsin commission says, in justification of its method:¹ "These early losses . . . represent the cost of the business in very much the same way as that in which the cost of construction represents the cost of the physical plant. One appears to be as legitimate and necessary a part of the cost of the enterprise as the other." The commission qualifies the application of this principle by recognizing that early deficits can be thus treated only when the conditions under which they were incurred are proper ones.² "When such deficits are due to abnormal conditions, or are due to bad management, defective judgment, extravagance, lack of ordinary care or foresight, unduly high capital charges, and other causes of this nature, it is manifestly clear that they should be accorded little or no consideration, in either the valuation or the rates."

The St. Louis commission which proved itself probably the most efficient municipal commission in the country also adopted this principle, and in its valuation of the property of the Union Electric Light and Power Company allowed \$1,000,000 for this purpose, saying: "These initial losses . . . are in fact a part of the

¹ Wisconsin Railroad Commission Reports, Vol. III, p. 624.

² Wisconsin Railroad Reports, Vol. IV, p. 585.

legitimate investment, and should be permitted into the earning value as a part of the investment."³ The California commission approves of the doctrine that early losses should be recouped to the companies in some way, saying: "That there are certain actual costs incurred in developing the business during its early stages, for which costs the utility is entitled to be reimbursed . . . seems too obvious for argument." This principle and method have also been adopted by the Georgia, New Hampshire and Ohio commissions.

The objection of the New York First District commission to this plan appears to be that thereby any close relation between the valuation used for rate making and the actual physical value of the plant may be destroyed. The commission holds that "the amount included for going concern should be limited to expenditures made prior to the time when operation begins," and that after that, the various expenses which go to make up "going concern" should be charged to operation.⁴ If the policy results in losses in the early years, the company should be permitted in later years to charge rates sufficient to offset its deficiencies below a fair return in the early years. The commission states that to include such losses in the valuation of the property, or to permit them to be capitalized "is absurd, leading to gross over-capitalization." The Maryland commission has followed the New York practice, and in some cases where early losses actually occurred it has increased the rates in order gradually to provide for and cover such losses. But in no case has it permitted the inclusion of such losses in the plant valuation.

The Wisconsin practice seems to be the more rational. If the early deficits incurred in order to build up the business represent the cost of the property in the same sense that the investments in material equipment do, that is, if they are equally necessary, then the natural procedure is to add the amount of such deficits to the investment in equipment, the whole to represent the total investment upon which the company is entitled to a return. It is true that to do so means that a return upon these early deficits will be saddled permanently upon the consumers. But if such deficits, assuming them to represent wise expenditure, are a part of the legitimate and

³ Report of the St. Louis Public Service Commission on Rate for Light and Power, 1911, p. 54.

⁴ Queens Borough Gas & Electric Company case, decided June 23, 1911, No. 2, P. S. C., Report 1st District, New York.

necessary investment in the property, this is certainly proper. It may be immaterial to the company which method is used, since by either method it is, in reality, compensated. But to the consumers it may be a matter of importance, for the New York method brings a discrimination against the present consumers as compared with future ones. Why should the consumers of today be burdened with a higher charge for the purpose of recouping to the company one part of its investment—early losses—any more than they should be burdened with a higher rate to recoup the value of its land or buildings, in order that the consumers of tomorrow may not be required to pay a return upon such part of the investment?

Both the Wisconsin and the New York First District plans contemplate that only the deficits incurred in developing the business shall be made up in some way to the company. The fourth method as applied by the New Jersey commission applies an entirely different mode of reasoning. This commission holds not only that early deficits should be added to physical value, but that expenditures to get patronage and to develop the business should be included in the valuation, whether or no such expenditures have ever been recouped to the company. This theory is announced in its boldest form in the Public Service Gas case⁶ decided December 26, 1912. In this case the commission announced that it would add about thirty per cent to structural value for "going value," such value to be "largely represented by the cost of developing the business, as distinct from the cost of securing the physical structure." The commission held, "we see no escape from the necessity of recognizing the intangible property designated as 'going concern value,' as well as actual physical structures similarly obtained, as constituting part of the present lawful possessions of a public utility, even though both the tangible and the intangible values were built up in the past, out of rates exacted from the consumers. . . . If these high rates in the past have been employed by the company to acquire intangible property in the shape of extensive patronage, that expectation of patronage is theirs, and on its fair value the company is entitled to a return. The 'going concern value' will then be largely represented by the cost of developing the business as distinct from the cost of securing the physical structure." The principle laid down is that this cost of "developing the business"

⁶ Report of the New Jersey Board of Public Utility Commissioners for 1912, p. 246.

should be added to the value of the physical property, even though expenditures for this purpose never produced a deficit, or a lack of adequate returns; in fact, quite regardless of what the returns of the company in the past may have been. "The going concern value may include the cost of soliciting business, cost of advertising, cost of inducing consumers to take service, cost of exhibiting appliances, cost of occasional free installations, etc." In other words, all such expenditures in the past are to be charged to capital account, even though these expenditures did not intrench upon a fair return. And this is because, "a plant with a business attached has a value greater than the value of the mere plant without the business attached."

This scheme calls for the most severe condemnation. It represents in the purest form, the capitalization, not simply of losses or deficiencies below a fair return, but of expenses. If all expenditures incurred by a company in order to secure and establish its business are to be added to capital value, then practically all expenses must be so treated, for practically every expense is incurred either to get or to hold business. All expenses of doing business are surely expenses incurred in order to hold the patronage, and are therefore responsible for the fact that the plant has a "business attached." The amounts expended for fuel with which to manufacture gas, the salaries of officials, the wages of employes, the cost of materials used, and all other legitimate operating expenses have been incurred either to develop or to hold patronage, and therefore, to "establish a plant with a business attached." For it is evident that if these expenditures were not made, there could not long be any patronage. It is obvious that to charge all operating expenses to capital would be unthinkable. But no differentiation can be made between the cost of getting patronage and the cost of serving the patronage, since without the service the patronage would not continue. Both are, properly, operating expenses.

The error of the New Jersey commission is due to its unqualified acceptance of the premise "a plant with a business attached has a value greater than the value of the mere plant without the business attached." This is always true in private business, but in the regulation of public utilities it may or may not be true. If a value in addition to physical value is to be allowed because there is a patronage established, it is evident that the cost added must be not the gross cost but the net loss, i.e., the deficits or the lack of adequate

returns due to developmental expenses. For it is only this amount which measures the *bona fide* investment, the sacrifice made by the owners of the property, in order to build up its business. To add the total expenditures made to develop the business regardless of the earnings which have been made means that all other operating costs incurred in the past, whether reimbursed to the company or not, should likewise be added to plant value: a preposterous proposal.

QUESTION BOX

1. Experience in the use of caps instead of plugs on dead ends and unconnected branch pipes; is there any economy or advantage in the use of such caps?

SECRETARY DIVEN: The secretary propounded that question. In going to a new city he found that instead of using plugs in branches, a short piece of pipe had been put on and capped. The speaker could not see the economy of that arrangement, and asked what the reason was. He was told that it was done because it was easier to take off. He believed that, because he had not been in that new location six months before six of them blew off of their own accord. The speaker had been in the water works business for about forty years and had never used that sort of an arrangement and was wondering why they were used and wondered if anybody else had used them.

2. What legal right has a water company to the use of public streets after the expiration of its franchise? Experiences of water companies whose franchises have expired, especially in cases where duplicate public works have been built.

MR. J. N. CHESTER: That depends upon the location, state or city in which you are and what the nature of the franchise rights is.

SECRETARY DIVEN: The question was asked whether they would have to stop doing business after the expiration of their franchise—if they would have any right to dig up the streets after the franchise had expired?

MR. J. N. CHESTER: In some states the courts have said they may, and in some others they have said they may not. There have been as many different decisions as there are states.

MR. GEORGE HOUSTON: The speaker did not ask that question, although he was glad to see it in the list, being particularly inter-

ested on behalf of his city where the franchise of the gas company is about to expire, and a great many of the people have the idea that all they have to do at the expiration of the franchise is to say, "Come on, boys, we will go down and take possession." We would really like to know where we are at; and if anybody knows a case that has been tried out on that line would appreciate the information.

MR. H. C. HODGKINS: There is not much doubt about where such a company is at; it is pretty nearly in court in a law-suit. It formerly would have had to go into a court of equity to acquire additional rights; and the way the question is stated the speaker does not think it had any standing whatever. The establishment of public service commissions in various states has in great measure superseded franchises and nullified a great many decisions, so that a great deal of the information contained in past decisions is of little value.

Wherever you have an indeterminate permit act, naturally any decisions prior to that are not applicable. If the state in which the franchise is located has a public service act that act should certainly define the rights under such franchise and after the expiration of the franchise; and if it does not then the old law prevails. So references to other states will hardly be valuable.

MR. F. J. CONNOR: The Sioux Falls case was a noted one, and the court in deciding it said, "This company goes out of the water works business on a certain date," and after saying that he gave the company the right for a year after the expiration of the franchise to have the pipes removed. The company removed about twenty miles of mains of sizes from 4-inch up to 16-inch and dismantled the entire plant. Of course, we had two systems for about a year. At the speaker's first installation as superintendent we had what was called the "old company" and the "new company." They were both doing business, and one was taking the consumers away from the other.

The speaker wants to say frankly and fairly, if any of you are fighting with a company, for the good of your community, if the old company has a good lawyer and is willing to spend lots of money, the lawyer will probably milk them, and the case will work out about like it did in the case of the Irishman who went to one lawyer and said, "I have a little trouble with my brother, and I

want to start a suit against him." The lawyer said, "I have your brother's case, but I have a good friend down the street, you go to him, and I will give you a letter of introduction." So he wrote a note and gave it to Mike to take to the other lawyer. Mike was a little curious, and he opened up the note and read it. It went this way: "You look after one, and I will look after the other." So that will be about the way with you that are fighting the company, and while the speaker has charge of a municipal plant, his best advice to you is, if there is any possible way to settle the thing, lay aside personal grievances and do not get into litigation; try to settle it in some way, and you will all come out better.

MR. J. M. DIVEN: It seems as if the last speaker left out part of that story; that there was an addition to that note to the effect that by and by the lawyers would have the property.

MR. E. E. DAVIS: We have never had much trouble about franchises but we sometimes have questions in dispute that come up for settlement that would keep half a dozen lawyers busy. The lawyers of Richmond are very kind to the speaker, who frequently makes decisions for them, and they abide by them. Some time ago a question came up in regard to a line of pipe that was laid to an annexed territory. The work was done under the supervision of the water works department under certain specifications as to sizes, etc., and disputes came up, and under the agreement any such dispute was to be handled by three disinterested parties, who probably would have been lawyers. But instead of getting three disinterested parties we handled the matter through the administrative board very satisfactorily to all concerned.

MR. W. A. PATTON: The speaker is responsible for this question, at least he submitted it to the secretary at last year's convention, and was disappointed afterwards in not being able to attend. He did not know that it had been carried over to this meeting.

The question is worthy of some investigation. Private water companies who have immense investments at stake are entitled to rights as well as municipalities. This question is well worth consideration because it affects vitally those who have their money invested in private water works. In the city of Cincinnati recently a case came up, the speaker cannot give you the exact style of the

case, but thinks it was a case where a company attempted to carry some pipe across the street to a neighbor, and it was decided by the lower court, and the party gained his point. The decision in effect was that he was a tax-payer and abutting property owner and had the same right to the streets as any one else; on the principle that the streets are public property, and as long as his pipes do not interfere with the general use of the street, as a tax-payer he has that right. Now that is a question that is well worth considering; and if this question cannot be answered at the present time trust that those who can give information relative to it will have it in readiness for the next meeting.

MR. W. F. WILCOX: The only decision that the speaker knows of bearing on the question is a decision in the case of the town of Canton, Mississippi vs. the Illinois Central Railroad, in which the Supreme Court of Mississippi decided that it was not within the purview of the railroad to use a street, because it was a railroad corporation and they will not allow a railroad company to use streets for the purpose of laying a water pipe.

3. What experience have you had in the use of lead wool for joints in cast iron pipe? Is it as economical and satisfactory as melted pig lead?

MR. C. W. WILES: That question was presented to the secretary at the request of a neighboring city of ours. They wanted to get some information on that subject as to whether lead wool had been used throughout the country on dry joints, and whether it was successful and as economical as hot lead. We would like to have the benefit of any information we may be able to collect as to experience with the use of lead wool in place of pig lead in making wet and dry joints on water lines.

MR. JOHN M. DIVEN: The speaker has found it so satisfactory, that in small jobs, such as setting fire hydrants, where there are only four or five joints to make, he has not used poured joints for some years; as you know, building the fire and getting the melting apparatus in position and operation would mean a large proportion of the work in the case of a small job as compared with the cost of the job.

The speaker had occasion to lay a line of 8-inch pipe under a railroad yard, some fourteen tracks in all, and in swampy ground. Great trouble had been experienced with pipes under tracks in similar situations and Ward joint pipe was used for this job. As a test of lead wool half of the joints were made with it, the other half being poured in the usual manner. Leaks soon developed in the poured joints, but none with the lead wool ones. Great care was taken in laying the pipe to grade, to get full joints and the lead wool was caulked in strand by strand, so that it was solidly compacted for the entire depth of the joint, something that was not possible with the poured joints. No gasket was used in either the lead wool or poured joints.

MR. OSCAR BULKELEY: The speaker used lead wool on lines of pipe from 8 inches to 12 inches in diameter, but gave up its use because caulkers could not do the heavy work required in caulking lead wool by hand. It's a long, tedious job. However, the speaker is of the opinion that lead wool may be used successfully by caulking with a pneumatic hammer.

4. Is it your practice to test new water meters or meters repaired at the factory, or do you rely on the factory tests? If tests of such meters are made, do they indicate that the new or factory repaired meters are accurate, or not?

MR. THEODORE A. LEISEN: In Detroit we test every meter before it goes out into service, and with very few exceptions our tests come up to the factory tests; in other words, we figure on getting within $1\frac{1}{2}$ per cent of absolute accuracy before the meter goes out, and we usually get that.

MR. A. A. REIMER: The speaker thinks there ought to be a very close agreement between the factory test and the shop test at our own plants, if the pressures and pressure conditions are nearly the same. For instance, in one case where the differences were as high as 4 to 5 per cent, it was found that the pressure fluctuated owing to the fact that at times in some other part of the factory the testing line was subjected to rather extreme changes in pressure, whereas our test conditions gave a practically constant pressure. As soon as those conditions were changed at the factory and they gave a

constant pressure, we got practically the same conditions and reached the same figures. We do not permit any meter to leave the shop and go into service until it has not only been tested but has met the requirements of the department for accuracy and delicacy absolutely. The repaired meters are also treated in the same way. As soon as a meter is repaired it is put on the test bench and brought up to proper specification requirements in every case.

5. Are meter bills of municipal water works a lien on property? If so, how are they regulated?

MR. J. N. CHESTER: That is a matter that depends on state laws, for in Pennsylvania they are, but in some other states they are not.

MR. GEORGE G. EARL; Our bills in New Orleans are a lien on the property by an enactment of the legislature. The lien has to be collected or filed in the mortgage office, to be protected against a sale of the property prior to its collection.

MR. J. N. CHESTER: That, we believe, is universally the case in connection with municipal ownership.

TOPICAL DISCUSSION

SERVICE PIPES

Experience with various materials, particularly steel or iron ungalvanized. Reasons for using iron or steel instead of lead; experience with material other than iron, steel or lead.

MR. A. A. REIMER: The speaker refrained from going on with that matter this morning because in that discussion certain remarks were made that did not seem to apply to the question particularly before the convention; but certain things were said this morning which the speaker wishes to reply to. Mr. Wilcox stated, or the practical effect of his statement was that there was nobody making wrought iron pipe today. Now the speaker's investigations in connection with the committee work for the Association have led him into several of the shops and foundries of the country; and he wishes definitely and positively to say that there are concerns making genuine wrought iron pipe. It will not do to give the name of any particular concern, of course, before the convention, we are not here for that particular purpose; but if any of you are interested in getting wrought iron pipe, that you will not have any bother with in using or testing it after you receive it, the speaker can tell you where you can get it and how you can specify it so that you will be sure to get genuine wrought iron pipe. You do not have to take steel pipe if you want wrought iron pipe, you can get wrought iron pipe and you can feel sure that you do get it. The speaker has specified a certain brand of pipe and received it with the maker's name marked on it.

MR. W. F. WILCOX: The gentleman misunderstood the speaker, who did not state that there was no wrought iron pipe to be gotten. He said he seriously doubted if there was enough wrought iron pipe to furnish everybody with it without putting them to considerable expense. It would seem that there are a great many engineers who undertake to lay a burden on the manufacturer which increases the cost of the work without there being any correspond-

ing advantage in so doing. Low carbon ingot steel will answer all the purposes of wrought iron pipe. The speaker does not remember the price, not being interested enough. He thinks in the majority of cases low carbon steel will be just as satisfactory wherever a man's local conditions do not warrant him in paying any extra amount or going to any extra trouble to get wrought iron; it is doubtful if anything is gained by going out of the way to get wrought iron. Hundreds of thousands of dollars have been paid out to test the comparative life of steel and iron. To go into the slightest discussion of that would bore the convention, and so the speaker will not undertake it, but he believes that any man in any city will do well to consider his own particular conditions.

MR. W. R. CONARD: Anyone who is using wrought iron or steel pipe can make a very simple test to determine whether they are getting wrought iron or steel pipe. Take one part of sulphuric acid to three parts water and immerse a short section of the pipe in the solution for six or eight hours. This will demonstrate very quickly whether it is iron, or steel, not positively always, but generally speaking, and quite conclusively. When you take the short section of pipe from the bath the pitting of the metal will show a more or less granular structure if it is steel; if it is wrought iron you will find a fibrous appearance. It does not take so very long to make the test, and you can demonstrate to your own satisfaction in that length of time just whether it is iron, or steel.

MR. W. J. HADDOW: You may profit by the experience of the machinist and arrive at the same conclusion in about two minutes with a hammer and chisel. The grain of the iron is arranged longitudinally; steel, as the previous speaker has said, shows little granular particles.

MR. C. W. WILES: Any man who cuts pipe or goes into a shop and puts a piece of pipe into the cutter can tell very quick whether it is steel or iron. Another method of test is by the use of a threading machine on a piece of pipe; the wrought iron will take a sharp, smooth thread. Wrought iron cuts and threads more easily than steel, and wears the cutting and threading tools less.

MR. RAYMOND W. PARLIN: The last speaker referred to something which has interested the speaker for some time. He has often

been told that even though genuine wrought iron pipe were specified it was very doubtful whether it would be received. Our foremen have often said that the pipe purchased in recent years was not as good as that which we used to get and their statements were borne out by the experience which two plants with which the speaker has been connected have had with its use. The old pipe lasted eighteen to twenty-two years while the newer pipe on nearby services went to pieces in from twelve to fifteen years. The speaker has several times noticed that the threads made by the dies on the newer pipe were not as smooth or as easily cut as those on the old pipe. This led him to believe that the metal in the newer pipe was a mild steel instead of wrought iron. Wherever trouble is experienced with internal corrosion of service pipes, and no corrosion takes place on the outside, it would seem that ordinary steel pipe lined with natural cement would be preferable to the wrought iron pipe generally supplied. Experience in Watertown, Massachusetts, and in several other New England towns indicates that this pipe will be practically as good at the end of fifteen or twenty years as when it was put in place, while the best wrought iron pipe often fills with rust within a few years. Such pipe can be purchased in quantity and lined by the repair forces when there is nothing else to do. The cost should not be more than that of the best quality galvanized wrought iron pipe.

MR. A. A. REIMER: Another interesting test can be made by those who have machine shops, you can make it very easily, take a piece of steel pipe and then get a piece of wrought iron pipe, and make sure that it is wrought iron pipe. Put the pipes on an emery wheel and you can see the difference in the sparks that are produced in the case of the wrought iron as compared with the steel. You will be surprised at the difference you get in those sparks. That is about the simplest test that you can work with for a quick test. You will never be fooled, because low carbon steel cannot possibly make the same kind of sparks that the wrought iron pipe will. That is one of the most positive tests that have been found up to the present time. In our committee work, this is one of the points that we brought up in connection with wrought iron and steel, and after you have seen the sparks once you can never be fooled.

MR. J. M. DIVEN: Let us hope that, when the committee makes its final report, there will be a recommendation that the manufac-

turers will follow, that every pipe be stamped, so that we will know who made it. As to the small demand for wrought iron pipe and the prices paid, no doubt the demand will be met by the manufacturers.

The speaker's experience in buying old-time pipe in the open market, as against the present steel pipe, is, that the old-time pipe would last about double the time of the new. We were sure that it was wrought iron pipe, because there was no steel pipe made then. We do know that there are certain manufacturers that do not make anything but wrought iron pipe. You are safe in buying from them; but in buying from the dealers you cannot be sure what kind of pipe you are getting unless there is a requirement that the name of the manufacturer be stamped on every length of pipe.

MR. R. J. THOMAS: We are using mostly wrought iron pipe for large services and driving wells, and have never had any difficulty in getting all we want. In buying, we specify that no pipe will be accepted unless every length is branded. The speaker is surprised to hear of any difficulty in obtaining wrought iron pipe. We buy a carload at a time. Of course the price is higher than for steel pipe but it will last longer and wear better. Occasionally we have tried steel pipe but it has not proved as satisfactory as the iron. From our experience, confirmed by the experience of others, as found in papers read here, and from those who have made tests for a length of time of wrought iron pipe, it has proven satisfactory. In regard to services for inch pipe and $\frac{3}{4}$ inch pipe we use lead lined iron pipe.

CARE OF VALVES

Packing and material used for packing; Lasting qualities of various packings; Setting of valves to permit packing without digging up the streets; Oiling valves, both stuffing boxes and gears.

MR. M. L. WORRELL: In regard to material used for packing valves, the most satisfactory one, one that has you may say life everlasting, is lead wool. Once you pack a valve properly with lead wool, your job will stand forever, something else will have to give way before it does.

MR. WILLIAM LUSCOMBE: Will the speaker please tell how many years he has used lead wool for packing valves?

MR. M. L. WORRELL: Since it was first put on the market, and have never had to pack the same valve again. Do not recall how many years ago that was.

MR. A. A. REIMER: That sounds good, but the speaker thinks we ought to have a little longer period of time to prove its value. We need the test of time. With us we specify high grade Italian hemp packing laid in tallow. We have had a twenty-five years test of that without repacking except for examination, and on the examination we found the tallow still has lubricating value.

SECRETARY DIVEN: Have you ever tried graphite mixed with the tallow?

MR. A. A. REIMER: Recently we have been adding that too; but do not think it necessary.

MR. W. J. CONNOR: Does the gentleman who suggested lead wool use any graphite or lubricant with the lead wool?

MR. M. L. WORRELL: In some cases, and in some not. The speaker has not found any difference in the work. It was the idea of one man we had to use both oil and graphite mixed with the lead wool, but it was rather mussy, and it makes just as tight a joint without.

MR. W. E. HASELTINE: Have you tried lead wool for packing fire hydrants?

MR. M. L. WORRELL: No, sir.

MR. CHARLES McDONALD: Have the members who used lead wool had occasion to open up and examine the job very often?

MR. M. L. WORRELL: The way we came to use lead wool the first time, was because we had not anything else handy to use out on the job, and it occurred to the speaker that it would be a good thing to try. He had not looked into it before, but used it again, and at the present time the engineer at the pumping station is using it; with a metallic packing, it answers the purpose very well. We are using it on both large and small valves.

A MEMBER: In 1907 we took out about 475 valves from 6 inches to 12 inches inclusive, and on repacking lubricated with tallow and graphite. We have examined the valves and the packing occasionally, and it seems to be in apparently as good condition now as it was when the packing was first placed. The valves, most of them, have been operated only at stated intervals when they were opened or closed.

SECRETARY DIVEN: Another question which might come up in this connection is whether the valve as it comes from the factory is packed as it should be with durable packing, or whether the valve should be repacked before putting it in service?

MR. RAYMOND W. PARLIN: While operating a plant in the Middle West it was found necessary to repack practically all of the valves even before they were put in place for the first time, as the water in the system corroded the valve stems, so that, on opening or closing, the packing was cut out and leakage started. In repacking the foreman used a small tight-fitting lead washer, followed by packing made of either lead wool or hemp, lubricated with graphite or graphite and oil, with another small lead washer on top of the whole to keep it in place until the packing nut could be well started. The main dependence was placed upon the graphite in this packing, and the results seemed to be very satisfactory.

The foreman who had had a number of years' experience with this material was of the opinion that no further trouble would be experienced.

OWNERSHIP OF METERS

A general discussion of who should own the water meters, and experience with publicly and privately owned meters. Care of privately owned meters.

MR. GEORGE HOUSTON: On the question of the ownership of meters, in order not to take up any more time than necessary to cover this point as thoroughly as possible in the fewest words, the speaker will read an extract from a paper of his that was read before the Central States Water Works Association at Cleveland in 1911, with reference to the ownership of meters.

Some contend that it is best for the municipality to retain the ownership of meters for the reason that it gives the city full control in the care and inspection of them, which it could not have were they owned by the consumer. We do not agree with those who hold this view, as experience has taught us that it makes no difference whether the city or the individual owns the meter, and, as fully ninety per cent of the meters in use in our city are privately owned, we feel as though we are quite well posted on the question.

When we first began the installation of meters we thought best that the city should own them, but we soon found that people were very careless about protecting them, particularly against frost, and as we were put to a great deal of trouble as well as expense by reason of such carelessness we set about to find some way out of the difficulty. We finally hit upon the plan of giving the individual the privilege of either buying a meter outright, or renting it. If he buys it he gets it at cost, and if he rents it he is charged an annual rental of 25 per cent of the cost of the meter and setting same, but is given credit for 40 per cent of all rents paid, which will pay for a meter in full in ten years. This, as you will probably conclude, is a modest way of forcing the people to own meters, but it has worked out nicely with us.

In handling matters in this way we have never had to make an appropriation for the purchase of meters except the first one of \$4000, as the moneys received from rentals and the sale of meters has enabled us to keep the wheels revolving, and have a supply on hand at all times, and as we buy them only as we need them, they are generally disposed of before the bill comes due.

We have never had any more trouble exercising full control over privately owned meters than we have over those owned by the city, and we find that parties who own their own meters, as a rule, take more pains in the setting and care of them than do those who rent them.

It might be well to state that we do not rent meters that are above 1½ inches in size, but require them to be paid for when installed, and so do not have any large expensive meters on hand.

If conserving the supply of water, by a complete metering of plants, were to be followed out by many of our cities, where a shortage of water now exists, it would be found, as we have found in our case, that they have an abundant supply for all present needs and will have for many years to come.

This paper was written three or four years ago, and the practice mentioned has been followed ever since, and the speaker doubts very much if you could go to our city and by vote of our meter users or water takers have the plan changed now, because they prefer to own their meters, as a rule.

MR. SEABURY G. POLLARD: Who repairs the privately owned meters under those conditions?

MR. GEORGE HOUSTON: The city, charging cost for the parts.

MR. GALLAGHER: Do you charge for the actual cost of repairs in addition? Do you charge for the time of the man making the repairs?

MR. GEORGE HOUSTON: Yes, in some cases.

MR. CHARLES E. McDONALD: Does the cost of repairing the meters become part of the cost of the water bill, or is the owner of the property sent a separate bill for repairing the meter? Does the cost of repairing the meter become part of the main water bill that remains unpaid?

MR. GEORGE HOUSTON: Of course we never file any bills as a lien upon property. If they fail to pay bills on time we shut the water off, and it remains closed off until some one pays the bill. We have had bills of that kind where the water had been shut off for ten years on account of non-payment of bills, and the claim followed the property right down. We have never had any trouble at all. In seventeen years our collections have averaged approximately \$40,000 for water and we have now uncollected less than \$300, \$240 as the speaker remembers it. The delinquent water bills are all collectible and will be paid up in a very short time.

A MEMBER: In that case, suppose a consumer should pay the part of the bill covering the water consumed, and refuse to pay the part of the bill covering the repairing of the meter, would the water be shut off just the same?

MR. GEORGE HOUSTON: Just the same. We refuse to accept any part of the bill unless the whole is paid. We have two methods of collecting for repair of meters. The city does not take off any meters that have been damaged by freezing; they require the property-owner or some one for him, it may be the plumber or any one else, to bring the meter to the office. Our men then repair the meter and we make out a bill and attach it to the meter and some one has to pay that bill before the meter goes out. In that way we have no big account for meter repairs to keep track of. In every case when repairs are made, for cause other than freezing, the meters are put back into service and a report of the time and material is made to the office. We add that to the next outgoing bill

and it has to be paid at the same time the bill for water is paid, regardless of whether the bill is being paid by the renter or by the owner of the property. If the renter pays the meter rental or repair bill, and is under obligation to the owner to pay the water bill only he usually collects or deducts the amount paid for the meter repairs, or rental, or both, as the case may be from the next rental paid for the property; so that in that way it balances up very nicely and makes no trouble to speak of. We certainly have gotten along nicely.

A MEMBER: In your charge do you charge back to the property owner in all cases, or to the consumer?

MR. GEORGE HOUSTON: Everything is charged against the property.

MR. THEODORE A. LEISEN: Do you take similar action in regard to a frozen meter or when it is damaged by hot water?

MR. GEORGE HOUSTON: The same procedure. We do not permit the meter to be taken out of the shop until the bill is paid.

A MEMBER: What is your method of adjusting bills, for the time meters are out for repairs.

MR. GEORGE HOUSTON: We average it.

A MEMBER: Do you average the daily consumption from the time it was put in up to the next regular reading?

MR. GEORGE HOUSTON: As a rule we take the average consumption during two quarters and then we average for two quarters; we take the quarter at the expiration of which the meter was taken to the shop for repairs and the quarter following, that is when it was reinstalled after the repairs.

A MEMBER: The speaker has been in the habit of charging for it during the quarter succeeding when the meter was taken out.

MR. GEORGE HOUSTON: Our ordinance provides that we are to follow the method of taking an average for a charge basis. "Or

other available information." Sometimes we have to deviate from the regular course, but very rarely.

MR. WALTER L. WATSON: Where does the consumer get his meter? Must he buy it from the city or any plumber, does he use his own discretion as to the make of meter?

MR. GEORGE HOUSTON: The city reserves the right to furnish the meters; they have to get them from the city from the smallest up to the largest size. We have for a good many years had three different kinds of meters from which they can make selections; so that not any one single kind is adopted as the standard meter or the one that they have to take.

MR. PATRICK GEAR: Would the last speaker state if when he has a meter that has been running along four or five years he then takes it out and inspects it.

MR. GEORGE HOUSTON: Once in a while we do but, not as long as the bills are running along in about the same ratio. If indicated consumption starts to go down when a party has been constantly quite a heavy consumer, we have the meter inspected to determine the cause, if possible.

MR. PATRICK GEAR: The speaker would like to know how you get around a case like this. Suppose we installed a meter in a building, which was occupied by the owner himself, his wife and a maid, and after this meter was put in it registered about 30 gallons per day per capita. During the summer months in the lawn sprinkling time, the meter registered 450 gallons per day per capita, and then the consumer would claim that there was something the matter with the meter. After a few years of service this same meter would come down to a basis where it would run about 75 gallons per day per capita and the consumer would claim that the meter was all right. But if you would look and see the condition of his lawn, you would surely say that the lawn was very fine, and the meter was no good. Of course we all know that every one likes to praise their own method. If a city or town rules that the consumer must buy his own meter, and those meters are sold at different prices, there is not any doubt that he will buy the cheapest meter, although

it may not be the best one. You will have a lot of trouble in keeping tabs on cheap meters, seeing whether or not they are doing the work laid out for them, and finding out if they come up to the standard. Any meter that has been working regularly for five or six years, should be taken out and tested.

In our city the manufacturing plants run pumps and when these pumps get out of order, the meters installed there must do all the work. In some of the plants the meter will register 200,000 cubic feet for one month and the following month may run 60 cubic feet, which would indicate that the meter was stopped. When we send out the bill to them estimating it on a six-months' basis, the manufacturer will come in and say that he did not use the amount charged for, and rather than have any trouble with him we cut it down some.

If the consumer owns the meter he may take it out when he pleases, but if you should want to take it out for a test, he would tell you very quickly that the meter belonged to him and that you had no right to touch it. Then all your troubles would start.

MR. FRANCIS C. HERSEY, JR.: In regard to the first part of this question as to whether the city shall own the meter, we could find out very quickly the situation in the places represented by officials here by asking first of all those who live in places where the meters are owned by the water works to stand up, and then ask all those who live in places where the consumer owns the meter; and this vote might shed some light on the question.

(Vote not taken.—EDITOR.)

MR. W. E. HASELTINE: That might be all right if we all approved of the method that we ourselves are using. In our case the consumers own the meters, but the speaker does not believe it the proper system.

MR. GEORGE HOUSTON: Mr. Gear ought to have entered the profession of the law rather than the business of managing a water plant, for he certainly would have made a very good lawyer. He asks questions in rapid succession and then he suggests the answers and draws the conclusion himself, that the only way for a city or corporation to have any control over their meters, without getting into a row with the man's wife or the man himself, is to let the

municipality or the corporation own them. Now the speaker stands here to say to you that a whole lot of the trouble that every water works man has is due largely to his own personality. If you do not believe in your own system, if you do not believe it is right, you certainly will have a hard job convincing the people that it is right; but if you are soul and body given over to the idea that you are right and what you are advocating is right, you will not have any trouble in convincing the people. We probably have less trouble in Kalamazoo over our right to take off a meter and look after it than is had in any city in the country, whether the meters are owned by the municipality or a private company, or by the individual. We simply give them the right to pay for the meter if they want to or else pay a rental to the city for the meter; but we control it just as much as if it was owned by the city itself. We certainly have less trouble along the line of getting the consumers themselves interested in the meter than we would have if they did not own it. It does not make any difference whether a large majority of the people here at this meeting live in cities where the meter is owned by the municipality or the corporation, or whether they live in cities where the majority of the meters are owned by the individuals; that does not make any difference as to the right of the question. As said in the speaker's first talk, it depends upon the individuality of the man whether he has trouble or whether he does not. The last gentleman that spoke said that in his city the meters were owned by the consumers, but he did not believe in it. He will have a hard time, the speaker will guarantee, in getting meters out of a man's place unless the city owns them, when he wants to inspect the meter.

MR. W. A. PATTON; If we were all situated as favorably as our friend in Kalamazoo, where they raise so much celery that all his patrons have their nerves quieted in advance, we might find that under those conditions we would be able to take out an under registering meter without a fight. But down our way we would have a law suit at the drop of the hat if we were to try it. The speaker therefore thinks it better for the company to own the meter, for then we can take out our own property without trouble.

MR. W. E. HASELTINE: In Wisconsin we are controlled by the railroad commission, which is a big commission and an extremely

good one. We are also interested in gas and electric property. We own our gas and electric meters. We would not allow consumers to own them if we could help it. We want to own the meters ourselves. It is much more satisfactory in the case of gas and electric companies and the speaker does not see why it should not be equally so with water meters.

MR. C. W. WILES: We have about 90 per cent of our meters owned by the company and 10 per cent owned by individuals. The speaker is free to say that he does not know whether we could stop them from buying meters or not; but has not tried to very much. If a man wanted to own his own meter the speaker has said, "All right," but he does believe in the ownership of the meters by the company; for this reason, if you have a meter that has been running along five or six years and you go over your books and find that the meter has been dropping behind, that meter ought to come out. We took out over forty this spring, because we thought they had been running longer than they ought to run correctly.

We found that 75 or 80 per cent of those meters had been running slow, so we took them out without asking anybody's permission. We simply recorded on our books that the meter had been changed and another meter put in. We did not go to the owner of the property about it and say, "We are going to take this meter out;" we simply go and take it out and put another in its place. If you were to take the meter out without putting another in its place you would have to estimate the consumption until such time as you did place another meter. One advantage of the company owning the meter is that there is no controversy over its ownership. If the customer owns the meter and it freezes you will have trouble when you go to take the meter out and average the water that is used while it is out. If you own the meter you do not have any trouble.

MR. GEORGE HOUSTON: Why don't you repair it in the first place? How many did you send back to the factory?

MR. C. W. WILES: We sent back fifty of them last year.

MR. GEORGE HOUSTON: Then your repair shop is not what it ought to be.

MR. C. W. WILES: We cannot repair a badly sprung brass meter, we have no appliances for bringing such a meter back to place. Most of those that we have had to send back have been large size meters. We find that it is much more convenient to take the meter out and put another in its place and then repair the one taken out when we get ready.

MR. GEORGE HOUSTON: Mr. Gear said that if the consumer paid for his own meter he would always select a cheap meter in preference to a better grade. We have meters that we sell for \$6.75, \$7.00, \$7.50, and \$8.75 for the $\frac{5}{8}$ inch size. Since the 17th of last June we have put in approximately 500 meters on lines where the people bought them. There has been but one of the \$7 meters put out, and about three of the \$6.75 meters, and they were put on places that the Board of Health had ordered connected with sewers, and insisted that a water supply be carried in. The properties in two of these cases had been taken over by foreclosure of mortgages, and were owned by men who lived east and they wanted the cheapest meters they could get. It is *not* true that the Kalamazoo people buy the cheapest, even if they do eat a lot of celery.

MR. HENRY P. BOHMANN: Milwaukee has about 161,000 meters in service, all of which are owned by the consumer. The speaker wishes to go on record that meters should be owned by the city. Our experience has proved that to be the correct position.

The Railroad Commission of Wisconsin has in every instance ruled that the utility must furnish the meter, and a special ruling was necessary for Milwaukee, for the reason that we would have been obliged to purchase a lot of old junk in order to get possession of the privately owned meters. The water department started out correctly. Mr. Benzenberg, city engineer, at that time, had charge of the water department, and selected what he considered the best meter. Several aldermen who happened to be plumbers were anxious to get the agency of different meters, and finally succeeded in getting a resolution through the common council compelling the consumer to furnish the meter. As the result of their activities we now have about thirty-five different makes of meters in service, good, bad and indifferent; whereas if the department owned and had the selection of the meters we would have confined ourselves to about two or three good types. The meters are furnished by the

plumbers, who charge anywhere from \$10 to \$20, whereas if the department owned the meter we would buy in large quantities and would furnish them for \$5 or \$6. Indirectly that would be of benefit to every consumer. We have thirty-five meter readers who read the meters monthly and report as to how they are registering. If they are not registering properly the next step is to take out the meter, send a written notice to the consumer, and ask him to sign the notice to have the meter repaired. The party has ten days to sign and send in that notice. If he happens to be a tenant it usually requires ten days before the notice comes in. In the meantime the meter is waiting in the shop. After the expiration of ten days it is repaired, and then it necessitates a second trip to replace that identical meter. In the meantime the water registrar is advised that the meter has been taken off temporarily and replaced, and then the account is averaged. This is a simple proposition in the ordinary residence; but out of our total revenue one-half is paid by one hundred large consumers. We have a number of them that are paying from \$20,000 to \$25,000 annually. It is very difficult to find a proper way or method of averaging the account when the customer is using from \$25,000 to \$75,000 worth of water a year. We notice that whenever a meter is taken off it is always claimed to be during the dullest season. The fact that gas and electric utilities furnish the meters is pretty good evidence that the water departments and companies should follow suit.

MR. GEORGE HOUSTON: Did you ever have or hear of meters that were owned by the city, those large meters, that would stop and would necessitate averaging the account?

MR. HENRY P. BOHMANN: No, the department keeps a sufficient number of meters on hand, so that when a meter drops in registration and we have to repair it, we take off the defective meter and immediately replace it with another meter, then the defective meter is brought into the shop and put in shape. Under our present conditions we have to replace that identical meter.

In case of meter repairs, we charge only the actual cost of repair, of which we keep a record of each particular job; then we charge the overhead expense. A meter repair job is like a doctor's bill, it comes unexpectedly; it is always unsatisfactory. We are spending something like \$60,000 on meter repairs yearly. The speaker

has a meter in his house that has never cost one cent for repairs. He would be willing to assign the ownership of that meter to the city with the understanding that they would replace it every time it needs repair; and does not see why every property-owner cannot assume the same position.

MR. H. B. MORGAN: The question of who should own the meter—the water department or the consumer, is probably troubling most of us. The speaker's experience is that the meter should be owned by the water department, for the reason that we then would have full control of it, and, if for any reason it became necessary to remove a meter and put another one in its place, we would not be compelled to argue with the consumer as to its condition, as in a great many cases you would have to do if he owned the meter, and in nine cases out of every ten you would utterly fail to convince him that his meter was not correctly registering the water passing through it.

At one time some of our consumers owned their meters and we always experienced a great deal of trouble whenever it became necessary to remove one for repair or to put another in its place.

In one particular case where the then manager of our company was discussing with the consumer the condition of his meter and the necessity of removing it for repair, he told the consumer how hard water acted on the brass in the meter and caused the meter to slow up and in many cases to absolutely stop. The consumer said to him, "Well, if your water has that effect on brass, what effect will it have on my stomach?" The manager was stumped for a second and then replied, "Well, your brass is not in your stomach."

Mr. Chairman, the speaker did not expect to enter into this discussion, but finds that he will have to keep out of this convention if he wants to keep out of discussions.

MR. WALTER L. WATSON: Somebody has well said that the consumer should not be expected to pay for the meter that measures water any more than as a patron of a grocery store he would be expected to pay for the scales that weigh the sugar.

MR. PATRICK GEAR: The speaker finds great pleasure in sitting down with his friend from Kalamazoo, and talking about the water department of that place. His department is something like ours

was some years ago. An old man who came to work for the department from its foundation was working in the street one day when a traveling man stepped up to him and said,

"Is this a municipal department, or a private corporation?"

"No, it belongs to John O'Brien and Mr. Hardy."

Now it would seem that it is the same in Kalamazoo and whatever this friend says is law in his town.

Mr. Kirkpatrick, who was the former superintendent and who is now manager of the City Gas and Electric Department, wanted to buy the 6-inch meter installed at his plant, but our department would not sell it. If we did sell it we would lose the \$60 per year rental charge.

SECRETARY DIVEN: Does the \$60 rental pay for any water?

MR. PATRICK GEAR: That is for rental on the meter. He used a large amount of water on the Fourth of July, so that we will get \$5 for the water used and \$60 for the meter.

From two concerns that we charge \$40 rental on a 4-inch meter, we receive about \$10 for the water used. You can see that if they owned the meter we would lose the rental charge.

It seems in this convention that it is very much the same as what General Hancock said when he was running for President, in the year 1880; he said that the tariff was a "local issue." The meter question is a local issue, and must be handled according to the conditions existing in the different cities and towns. Everybody thinks that his own department is all right. The speaker never had any trouble with the people in Holyoke, but was afraid that our friend from Kalamazoo may have in his town, and wanted to advise him to come over on the popular side of municipal ownership of meters.

MR. E. E. DAVIS: Probably the experience of my town dates back with regard to meters farther than that of any city in the United States outside of New York. The first meter that ever came to Richmond was made in 1858, and was a 1-inch meter and weighed 500 pounds. It was too "bunglesome" and too heavy. It was tried for a while but never was satisfactory. In 1874 Mr. John Kelly came to Richmond and the superintendent of the water works gave him an order for four meters. The speaker was the plumber

for the department at that time and his duties being almost anything from superintendent down to plumber, he put the meters in that we bought from Mr. Kelly and used them to test for waste. We also bought a $\frac{1}{4}$ -inch Hartford meter put it on a livery stable where the man was paying under the ordinance \$65, and the meter reading at the rate of 25 cents per 1000 gallons made his bill run up to \$125. So then we started to convince the city council that there was a great deal of waste; but they would not be convinced. In 1888 the city set aside \$1000 from its construction account for meters, giving them to parties that asked for them, and charging them \$2 a year for the use of the meter and 25 cents per 1000 gallons for the water. The large factories began to see where they could save money provided that the city would reduce the rate, and they put in their own meters. We were charging \$2 a year for rent of meters, but the city attorney decided that we could not collect that because we charged in advance; so the \$2 rent was taken off and the parties that got meters from the city paid the regular straight rate.

A good many years after that our pumpage rose to a tremendously high figure while the pressure was going down. The speaker made numerous tests to demonstrate to council that waste was going on and that meters should be adopted; but they decided then that they would not take any action but would allow the people to purchase their own meters, and a great many people bought meters. The lowest bill that any of them had was \$3.38 a quarter ordinance rate. We charged by the month, and the majority of the bills were reduced to 65 to 75 cents a month, through meters. One man paid \$1.68 a year for water through his meter. An old man on a side street, that ran a shoe shining place, did not get any reading from his meter and he paid 38 cents for the entire year. We finally got the city council interested in the idea that waste was going on, and they voted us \$15,000 to purchase meters. We put the meters on, and charged a flat rate of 15 cents per 1000 gallons. Everybody was working then for the meters. The question arose as to the meters purchased in between the time that we originally purchased when we paid \$13 a piece for them as to whether a cheaper meter would be acceptable to the city. That was in the days before the disc meters were invented. After the disc meter came in we stopped buying them for the consumer and let the consumer buy for himself. The city would put in the meter, and then the question would

come up as to who was to pay for it. That question has been up since 1885, but never decided.

We have tried every way in the world to find out which is the best way of controlling the meter? The city puts in the connection between the street and the property, but the plumber furnishes the lead pipe to make that connection. We furnish the meter and put it at the curbstone. We charge them a minimum rate of not less than \$8 a year. If a consumer wants a meter put in for his premises larger than 1-inch he pays the cost not only of the meter but the connections, outside of the labor. The fire underwriters and insurance people have all been jumping on the speaker because he has positively declined to allow an insurance connection larger than 6-inch for fire protection.

Another question that has come up about meters is as to who shall keep them in repair. The city of Richmond keeps all meters in repair up to 2-inch. If a meter larger than 2-inch is found not working due to wear the necessary parts are ordered from the factory and the bill is sent to the consumer. If a consumer has two connections in his house the city furnishes him one meter, and he buys the other. He does not know what kind of a meter he buys because the agents in Richmond all charge you the same for all kind, \$8.40 for $\frac{3}{4}$ -inch meters.

Municipalities that own their water works should own the meters, because then there is no question about the repairs or anything else. We put meters on to prevent waste; the city of Richmond has saved nearly a half million dollars for a reason that all of you gentlemen are familiar with. If you are going to furnish water at flat rates with no restriction except individual inspection you will make a serious mistake, for meters are inspectors in themselves and always on the job.

If a meter stops we average the bill, and settle on a basis of the average for the preceding six months; or if the consumer objects to that method we will let the meter run for thirty days and make the average in accordance therewith.

We endeavor to keep the meters in the best condition that we can. Sometimes they can be repaired right at the customer's premises; at other times it is necessary to send them to the shop.

Having had experience with meters since 1874 the speaker thinks it is best for the municipality to own the meter; or if it is a private meter the city should control it and keep it in repair.

CURB COCKS

Necessity of installing, their use and care; advisability and practicability of placing shutoff in the streets, at or near the main, to take care of service leaks outside of the curb line; cost of street boxes, keeping record of them, etc., as compared with curb boxes.

MR. J. M. DIVEN: When the speaker started in the water works business the service shutoffs were all at the main, and about his first work was locating and making records of their location. Later the shutoff boxes were all removed to the curb line, curb cocks being installed. It was at times difficult to locate and clear the shutoff boxes in the street, and it was thought that by putting the shutoff at the curb all troubles would be ended, that even the record of their location would be unnecessary. This proved to be a mistake, as even at the curb there are troubles and records of locations are nearly if not quite as necessary as in the street.

Troubles with leaks between the curb and main have led the speaker to wonder if there might not be some advantages in having the shutoff at the main. It is often necessary to dig up the street to shut off a service at the corporation cock, or to shut off a block or more of main pipe, to make repairs to a leaky service when the leak is outside of the curb cock. A shutoff at the main would obviate this and in many cases save cutting two holes in a pavement, as the one over the leak would be the only one necessary. Shutting down mains is not good policy and should be resorted to as seldom as possible; then too such shutoffs do not please the consumers, who are put to considerable inconvenience and annoyance.

Heavier boxes would be required if located in the street, and the question is whether the cost of extra excavations and the annoyance of shutting off sections of the distribution will offset the additional cost of shutoff boxes located in the street.

MR. OSCAR BULKELEY: The speaker would like to bring up the question of the method of manufacture of lead service pipe. He believes there is no standard of manufacture at present. There is no uniformity in the hardness of pipe that is furnished, and, when put up in reels, the joints that were made when two lengths of pipe were connected in process of manufacture are often found to have been very poorly made, so that the two ends of pipe joined together

in the reels may actually fall apart when subjected to slight bending. It would seem that the lead flange union couplings which are being used to a large extent now require a more uniform quality of lead than the old wiped joint. The speaker believes that standard methods of manufacture should be adopted for lead pipe.

SECRETARY DIVEN: Frequent attempts have been made to get information concerning the manufacture of lead pipe, especially standards as to strength, that is, the heft or class of lead to use for the different sizes, along the lines of the standards for cast iron pipe. We are in the habit of purchasing AA, AAA or even heavier pipe, without any regard to the size, though in the different classes the thickness of wall of pipe is the same for all sizes. It does not seem reasonable that as thick pipe wall is required for a $\frac{5}{8}$ -inch pipe as for a 2-inch, but we have no tests or standards to guide us in the purchase of lead pipe. What we need is a standard similar to the one established for cast iron, giving the class of lead to use for different sizes and different pressures. This report or standard could also include standard for quality of metal used, just as the specifications for iron pipe specify the quality of metal.

This question has been brought up with the manufacturers, but they seemed unwilling to go into the matter, and no member of the Association has so far been found to take it up; to make the needed tests and analysis of metal. Most of us are undoubtedly using the wrong classes of pipe, too heavy for small sizes and too light for the large, for we are mostly using the same class in all sizes. The Association will do a good work if it can establish standards to guide users of lead pipe.

MR. M. L. WORRELL: Water pipe cast in 16-foot lengths has recently been put on the market, and the speaker has used some of it and found some economy in its use, about 78 cents per ton in 6-inch pipe, and would like to hear the experiences of others that have used it.

MR. J. M. DIVEN: As the weight of the bell is about 10 per cent of the weight of a length of pipe, there would be a considerable saving in weight of metal bought when longer pipe than the usual standard 12-foot lengths was used. There would also be a considerable saving in lead for joints, with 16-foot lengths there would

be a saving of one joint in every four lengths over 12-foot pipe. This saving is easily figured, both in material and labor, for the different sizes of pipe. In larger sizes the additional weight to handle might be a disadvantage; also, the lines would have to be straighter, as there would be less chance to offset at joints. The speaker can, however, give nothing from personal experience, but trusts that such members as have used the pipe in the new lengths will give their experiences. We all want to save all we can in our construction costs and are keen for any methods of manufacture of material that will assist us in this.

MR. W. F. WILCOX: The speaker is not a pipe manufacturer, but the company with which he is connected sells a great deal of pig iron to a foundry company. Probably the reason why the length has not been increased is because the smaller foundries have to build the spigot end of the pipe, and over a certain size your specifications require that a certain percentage of the spigot ends may be cut off.

The hardest part of the casting of pipe is to get rid of the honey-combed ends, and with the present methods 12 feet has been established as an economical length. The speaker believes we will save more money by letting the pipe manufacturers work out the pipe lengths for us than we would by attempting to dictate an arbitrary standard. The pipe makers keep a large laboratory and they study their manufactured product day in and day out. The speaker would rather have the opinion of some of the founders as to cast iron pipe than that of all of the testing societies there are. The founders live with the pipe, they know it, they are making the pipe and they know how to make it. They pile up all of their cast iron in different piles and each pile is numbered. A detailed analysis of each pile is carried, and they can tell you if you give them a number of pipe in the large size what mine that ore came out of, the day it was manufactured into pig iron, the day it reached their yard, how they made up that mixture, and the test both for tensile and cross breaking strain. They are anxious for any man that ever buys a foot of pipe to give them the history of any failure there is, and there have been instances where they have spent hundreds of dollars following up a small break simply because there was something in the pipe that, to the minds of pipe manufacturers, indicated that something had got by them in the manufacture of that pipe. The

speaker has seen pipe 36 inches in diameter sent back to the scrap yard after it had been accepted by the inspector in one of the largest cities in the United States.

If you will go to one of those pipe foundries for a week you will find out that they could reduce their percentage of rejections if they would turn over to you the pipe that your inspector is willing to take. The speaker has lived close to a pipe foundry and has been able to see how they study their manufacture. It is wonderful how they make pipe; the care, thought, and endeavor that they put into its manufacture.

Some large cast iron pipes break in the most peculiar manner. The speaker had one break of 17 inches. It was a crack right down on what he calls the belly of the pipe; a little rock not much bigger than the end of one's thumb did that. We used the hammer that the expert hammer men use in breaking up big castings to break that pipe, but could not do anything with the hammer. We put a stick of dynamite on the pipe before we could break it up.

The people who are making pipe are glad to receive any suggestions. It would be well for this convention to go to Birmingham and see how they make the castings and how they are endeavoring to make them the best they know how. They will be glad to have you join with them in making specifications to get the best results in the most economical and practical way. As the manufacturers develop and find that there is demand for a better pipe they will all try to meet the demand. Every man that has been in the water works business twenty-five years will tell you how they used to use wooden pipe in 1820, and the old men in the water works business will tell you how when the new-fangled steel pipe came out the older men said, "Well, we have been laying cast iron pipe a long time and we will let the boys try that new pipe."

Control of a pressure wave in an 18-inch water main $5\frac{1}{2}$ miles long from motor driven turbine pump. When power goes off at power station the pressure drops to 10 feet, and rebounds up to 420 feet, each wave less until pumping against a head of 267 feet with a friction of 32 feet on 299 feet.

MR. W. F. WILCOX: We had an experience with fluctuation of pressure in a 52-inch steel pipe which had a tendency to flatten as the speed of the pump plunger decreased and to assume a circular

shape when the speed of the plunger was at its highest movement. We put on an air chamber which had ten times the diameter of the displacement of the plunger, and ever since that time have had no movement in the pipe. The movement of this pipe was rather peculiar. The general manager sent a message one day to start out on that line and investigate why that pipe was moving two inches. The speaker went out and put pointers on it and set a level on top, and found that the pipe moved $\frac{5}{12}$ of an inch. But after watching it for some time it was found that it was moving an inch and a half. There was a crack right down the back for the entire two miles of the length of the pipe. The engineer with whom the speaker was located had advised anchoring the pipe. We anchored it with concrete anchors. We found the only remedy was to provide an air chamber of ample capacity to take the surges of the pump. We put a check valve at the end of the pipe next to the reservoir and air relief valves to relieve any air that might accumulate in the pipe. It is now five years since that pipe was laid, and we have never had to spend a nickel on it.

MR. GEORGE HORNUNG: The speaker has had some experience in controlling fluctuating water pressure in pipe lines, one, in particular, a description of which may interest you and also be of some information to you.

This occurred some 15 years ago, when the speaker served a company as general manager of three water works, two of which were being supplied by impounded water collected from a water shed extensive enough to create a lake of considerable dimensions. The main pumping plant was located alongside of this lake and delivered the water to both towns through a single pipe line 20 inches in diameter. The first town reached was one-half mile from the source of supply, and the other 20 miles therefrom. A stand pipe 8 feet in diameter and 140 feet high, was located near the first town and connected with the supply line in common to both towns. At the farthest town the water was received by a circular reservoir 100 feet in diameter and a depth of 12 feet. From this basin, the water was repumped by a second pumping station into a stand pipe 25 feet in diameter and 100 feet high, and connected up in the usual way with the distributing pipe system of the town. It may be well to note that the country is practically level for miles around, and absolutely devoid of any natural elevation for locating either

a reservoir, an elevated tank or a stand pipe; hence, as it was, the maximum amount of water that could be delivered by the pumping station to the farthest town was limited by the carrying capacity of the single line of pipe, and also by the head of water carried in the stand pipe.

It is obvious that under the existing arrangement, the town near the stand pipe would be well supplied with water and pressure, whereas the farthest one, would have its supply greatly restricted. These two plants, arranged as has been explained when the speaker was placed in charge of them, had been operated in that way some 18 years. The speaker soon discovered that the largest and farthest town was not being sufficiently supplied with water, and that the shortage was attributable to the lack of pumping capacity, and also to the carrying capacity of the long supply main and that consequently large expenditures of money would become necessary to give the proper relief, and to bring that about either a duplicate main would have to be put down, or the height of the old stand pipe greatly increased. To do the latter was found to be impracticable and unsafe, and to construct another pipe line would entail an expenditure of at least \$250,000.

On an examination of the pipe line in use, it was found that it had ample strength to sustain an additional water pressure of at least 25 pounds over that which was being carried. It was finally concluded to enlarge the pumping facilities at the lake and install an additional pumping engine of 5,000,000 gallons capacity, and to connect it, with the other engines at the station, to a 20-inch pump main so as to by-pass the water around the near town, using the stand pipe and a stretch of the old force main, with a pressure reducing valve properly placed, to supply the latter town. In this way a gravity main was converted into a pump or force main 20 miles long, which, with the higher pumping pressure made use of, furnished the desired amount of water to the second or farthest town.

The question arose with the contractors for a new pumping engine, whether it would be practical to pump directly at the proposed rate through this abnormal length of force main, so as not to burst the pipe by the oscillation of the column of water in such a long line of pipe.

The speaker explained to them how he expected to safeguard this pipe line against any water ram, which would be by the inter-

vention of an air vessel made of riveted steel plate, through which all of the water would be pumped. This air vessel to be located at the pumping plant, and to have a diameter of 5 feet and a height of 30 feet or more; and that a steam driven air compressor would keep the vessel supplied with air down to a point somewhere above the tops of the receiving and discharge nozzles riveted to the base of the vessel. The arrangements as detailed were successfully carried out, and after they were put in operation the expected results were fully realized, and continued so during the speaker's connection with these plants, which ended some four years thereafter.

A recording gauge showed that the terrors of the water ram so commonly accepted and feared by water works operators can be fully controlled and its damaging effects reduced to nil.

MR. E. E. DAVIS: We had a 36-inch pipe lying out on a lot for about two months. The keeper of the reservoir called the speaker's attention to a little crack on the end, about 4 inches long, which had passed the inspector. Six months later that pipe was cracked 6 feet, and it just kept on going; it was the only one of forty pieces of pipe that showed any such defect. One of them had a crack that barely showed. That pipe was laid out in the yard and six months afterward split open from atmospheric action.

The speaker had a very peculiar experience with an air chamber. He had the very difficult job of putting a 20-inch main in the bottom of a river. The river bed was composed of rocks. We put in concrete blocks and filled them up with rip-rap on each side so that the water would go over, and turned 90 pounds pressure on and it stood for some time. We reversed on the lower surface and put on 70 pounds. The speaker was called by the keeper of that reservoir who said that the water was all running out of the reservoir. Upon being asked, "Where is it?" He said, "On the 24-inch." Knowing what the trouble was, the speaker went down to examine the 20-inch pipe in the river and when he got there found that a piece had been blown out of the side of the pipe. It was a water ram that caused that. Two men ran away when the speaker came up, and it occurred to him that they had been shooting, and that possibly some wild shot or bullet had struck and burst that pipe; but he could find no mark of where any bullet struck. There was a 6-inch domestic sprinkler near by and the speaker went there to examine it and looked at it very closely. He called to the engineer and

asked him how he got the air in that sprinkler head, and was told that there was a valve cut in the shape of a funnel that fits over the top where the 6-inch pipe comes into the valve. When the water is on from the 6-inch water supply the pressure is about 90 pounds, but the air pressure is only 35 pounds on the sprinkler heads, and the difference in area of the valve that governs the 6-inch opening is sufficient to make up the difference of 55 pounds to the square inch on the contrivance that holds the valve. It was also stated that the valve could not be closed suddenly, but it was found that in trying the sprinkler heads when the air was exhausted it did shut off the sprinkler heads and the water supply very suddenly. The installation of an air chamber was insisted on and after it was installed the trouble ceased.

LEAKY PLUMBING

Enforcing rules concerning leaks in plumbing, by fines, shutting off water or other means.

General discussion of inspection of plumbing and reduction of leaks in unmetered buildings.

MR. JACOB KLEIN:¹ Investigation shows that more than fifty per cent of all waste of water in cities is due to leaky plumbing and to water loss from roof tanks. Leaking toilet tanks are the cause of a large proportion of this loss. Leakage in toilet tanks is not easily discovered, as some types are almost noiseless. Careless management within buildings, especially during periods of extreme temperatures when faucets are allowed to run full in order to draw the water, hot or cold, as required, is also the cause of the loss of a large amount of water.

Owners of buildings when installing their piping should be required to space the hot and cold water lines at least one foot apart. When owners make their application for use of water, they should be required to sign an agreement to prevent all waste of water and waive claims for damage caused by shutting off the supply in case of failure to comply with the notices to repair leaks.

House to house inspection to detect leaks in fixtures and unnecessary use of water in buildings has been found effective.

Inspectors assigned to examine plumbing in buildings should be

¹ Chief Inspector Bureau of Water, New York City.

familiar with its installation, and also have a knowledge of apparatus consuming water.

Notice should be left by the inspector with the owner or occupant when leaks are discovered, or when apparatus requiring water for its motive power is found in unmetered buildings. Notices in duplicate and carbon copied by the inspector in the field, have been found practical. When an inspector finds leaks on account of defective plumbing, or locates a water motor or ram in an unmetered building, a notice should be left notifying the occupant that the leaks are to be repaired and the apparatus removed within three days from the date of service, or a penalty of Two dollars per day would be imposed for each and every day such waste is allowed to continue. If the waste is allowed to continue after the imposition of the penalty, notice should be served that the water supply will be cut off.

Experience has shown that leaks are repaired by the consumer after the first notice is received, and it is only necessary to impose a fine in a small percentage of cases.

MR. J. M. DIVEN: The speaker fully agrees with what Mr. Klein says about leaking toilet tanks being the cause of a large portion of the waste due to leaky plumbing. As a test of this he on several occasions put meters on direct supply to toilet tanks both at his own residence and at waterworks offices. One such tank recorded a flow of over 1100 gallons per twenty-four hours. This tank had been specially fixed to cause the large leak, but while this leak was going on there was no annoyance, from noise or otherwise; nothing that would cause a consumer to repair the closet for his own protection. This, of course, is an extreme case, but is a possibility. The city pressure where the test was made ranged from forty to fifty pounds.

DISCUSSION

OBSERVATIONS OF SOME EUROPEAN WATER PURIFICATION AND SEWAGE DISPOSAL PLANTS¹

BY EDWARD BARTOW

A MEMBER: What amount of iron is in the Berlin water?

MR. BARTOW: About two parts per million, but they are very particular, they do not want any.

A MEMBER: At the Dresden plant, how much is the turbidity.

MR. BARTOW: The Dresden plant has a well water, which is clear when it is first drawn, the manganese separates on exposure to the air.

¹ Paper published in Vol. 2, No. 1, March, 1915, *Journal* at p. 13, etc.

DISCUSSION

THE YONKERS WATER SUPPLY AND ITS FUTURE DEVELOPMENT¹

By D. F. FULTON

MR. EDWARD WEGMANN: Mr. Fulton has pointed out the difficulties which Yonkers encounters in trying to increase its water supply. The sources which would be suitable for this purpose have been acquired by the city of New York, and Yonkers is, therefore, obliged either to buy the additional quantity of water it requires from New York, at a high price, or to go to a considerable distance for a new supply. Under these circumstances there was nothing left for Yonkers to do but to develop its present sources of water supply to their utmost limit, and to trust that, in the course of time, a metropolitan water board, similar to the one of Boston, Massachusetts, will be created to take charge of the water supply of New York and of the nearby towns and cities.

The manner in which Yonkers intends to increase its present supply has been described fully by Mr. Fulton, and leaves little room for discussion. The only feature of the proposed work which involves difficult construction is the proposed earthen dam, which is to raise the high water level of the Grassy Sprain Reservoir 40 feet. This dam is to be built about 350 feet downstream from the present dyke, and will have a length of about 1070 feet, and a width on top of 24 feet.

If the speaker is correctly informed, the dam will have a height of about 90 feet above the surface, which will place it among the high earthen dams of America. Most engineers will agree that it is more difficult to construct a high dam of earth than of masonry. With the latter material, a leak through the dam causes usually only a loss of water; while with the former material, a leak may lead to the failure of the dam. In order to prevent undermining an earthen dam should be provided with a masonry or puddle corewall, which should be carried down to an impervious stratum.

¹ Paper published in Vol. 2, No. 1, March, 1915, *Journal*, pp. 1-8.

At the site selected for the Yonkers dam, rock lies at a distance of about 90 feet below the brook, and as the rock valley is wide, there is a large quantity of material overlying the rock. This material is sand of varying degrees of coarseness, and much of it is so coarse, that water flows freely through it.

It would be very expensive to dig a foundation trench to rock for a corewall through such material. Mr. Fulton states that it has been suggested to obtain a cutoff for the dam "either by driving steel sheet piling to rock, or, in the deeper part of the valley, by sinking a connected series of caissons and filling them with grout or concrete." If the material overlying the rock were uniform, that might possibly be done. But the speaker is told that this material is a glacial drift, containing more or less boulders. It is very doubtful, whether steel sheet piles could be driven 90 feet deep through such material, so as to make a practically watertight cutoff. If caissons were sunk, the work would not only be very expensive, but would involve much difficulty in getting the caissons down vertically to rock, so as to make a tight cutoff. Quicksand or a sliding of the sand, would deflect a caisson from the desired position. At the Hauser Lake dam, caissons for a cofferdam were sunk to a depth of 70 feet, but that was through water. It would evidently be more difficult to sink a caisson through sand, quicksand and boulders to a depth of 90 feet.

In drawing attention to the difficulties that will, doubtless, be encountered in constructing the proposed dam across the Grassy Sprain, at the site selected, the speaker does not wish to imply that this work is impossible, but it will be very expensive, and if it is not done properly may lead to the failure of the dam. The present Grassy Sprain Reservoir has been formed by an earthen dam constructed on similar ground to that at the site of the proposed dam; but it stores only about 50 feet of water, and when the depth of water at the dam is raised to nearly 90 feet undermining of the dam may occur, which would not take place with the lower head.

Many failures of earthen dams have occurred, even when these works were built by good engineers. The terrible disaster caused by the rupture of the Johnstown dam in Pennsylvania is the worst case of this kind that has occurred in America. This dam was 70 feet high. It was ruptured by water flowing over its top, after an unusually heavy rainfall. In England one of the most notable failures of an earthen dam is that of the Dale Dyke dam, which

was constructed for the Sheffield Water Works. This structure was 95 feet high by 1254 feet long. It was 12 feet wide on top and about 500 feet wide at the bottom. Both slopes were made $2\frac{1}{2}$ to 1. In the investigations that took place, after the rupture of the dam, the greatest engineers of England testified as experts, but their opinions, as regards what started the failure, varied very much, and this question was never finally settled.

DISCUSSION

THE ACQUISITION OF PRIVATE WATER PLANTS BY MUNICIPALITIES¹

BY B. M. WAGNER

MR. EDWARD WEGMANN: This paper is an excellent one. While most of the facts are known to people who have studied the subject, it would be very interesting if there were a bibliography of all the articles that have been written on the subject of valuation. Recently the speaker had occasion to make a valuation of six water plants that the city of New York is about to acquire, and the rule given by the corporation counsel was to find the reproduction value minus depreciation. In doing this it was not a question of one man's opinion, but the superintendents of at least five of these companies carefully went into the matter and gave their ideas. The object was to get a valuation that was not the opinion of either party, but would give the Board of Estimate and Apportionment an idea of how much it would have to pay for these water plants.

Of course the original and present cost is easily found by the correspondence, but the difficult thing is to find the depreciation, and this is a matter that no living person can accurately tell. It is simply a matter of opinion and judgment.

Take the important matter of the life of cast iron pipes, you find in New York City pipes that were laid prior to 1842 that are not coated and yet are in almost as good condition as some of the modern coated pipe. These pipes were made of imported Scotch pig and are 70 years old and still in service. The speaker's first assumption as to the life of pipe was an average of one hundred years. We have pipes along the river front that will not last thirty years. The chief engineer of the Board of Estimate and Apportionment limited the life to seventy-five years; the five superintendents referred to all thought one hundred years was fair; but they all considered that seventy-five years was not a fair assumption.

¹Printed in Vol. 2, No. 1, March, 1915, *Journal*, at pp. 25, etc.

Now with reference to the item of steam pumps, a steam pump that is kept in good order and has been in service perhaps only three or four years, is, usually, in better condition than the day it was first installed. The way we finally figured that was to allow no depreciation for five years where the engine had been in moderate use and kept in prime condition, and thereafter to make a depreciation of 3 per cent per annum, placing the life of the pump at 38 years. Now those steam engines have been in service over seventy years in certain cases; but when you take the element of obsolescence into account it is a very grave question whether it would not have been better to have replaced the pumps long ago.

Then comes the question of the life of a hydrant. Of course we all know that hydrants have been made that remained in service forty years; but we finally arrived at a fair average of twenty-five years.

And so on down the line. These figures are not the judgment of the speaker alone, but were made in coöperation with those other men.

The value of every size of pipe from 4 inches to 36 inches was taken into consideration, and it might be interesting to add a little synopsis of those figures. It is a matter of opinion, and of course all will not agree. The value of a man's opinion is based upon his experience. However, it may be stated that those companies were very well satisfied with the general result. The president of the largest company, after having had two other estimates made, found that they varied only 1 per cent. The city did not intend to pay for those things now and was not trying to cut down every item, but was trying to arrive at a fair valuation for everything from a steam gauge to a 10,000,000 gallon pump, to put a fair value on it and include a fair depreciation. Mr. Wagner's paper gives the general principles on which this is done very admirably. This question of reproduction value, of course, is only one of the things that the company must consider. They must consider the original cost and the market value on the books and submit to the Court the different ways of looking at it. The final judgment, of course, rests with the Court. It would be interesting to hear what some of the members here think about the average life of pipe and the life of steam pumps in ordinary practice.

MR. JOHN M. DIVEN: In the opinion of the speaker the hydrants that were put upon the market over forty years ago are doing as

good service now as they ever did. In Troy we have pipe that was laid in 1833, over 80 years ago. We had occasion to make a six-inch tap on one of these old pipes, and found it to be in good condition and its carrying capacity very little curtailed by age. As to pumping machinery, it is doubtful if a pump is ever worn out, because almost always its capacity is outgrown before it wears out. The speaker does not recall any pump that was ever thrown out because it was worn out, but knows hundreds that were thrown out because their capacity was exceeded.

MR. WILLIAM H. HENBY: Will Mr. Wegmann please state in regard to the acquisition of these plants what consideration was given to private rights of way that have been secured by a holding company, private rights of way or easements that have been acquired.

MR. EDWARD WEGMANN: That question has been raised and the value of the real estate determined by the comptroller of the city of New York, in a case in which the speaker was concerned. The only thing that we were asked to figure on was the physical plant. That question was not brought up by any superintendent, and in fact our tendency was to rather make the estimate large than small, so as to cover omissions that would be brought up in the final taking over of the plant. New York is going to pay for those works, but at the final finding items will be brought up that we overlooked, but everything almost that you could name in the line of water works, from a pressure gauge to a 10,000,000 gallon pump is included in that estimate.

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THE ARSENIC CONTENT OF FILTER ALUM

EDWARD BARTOW AND A. N. BENNETT

Specifications requiring arsenic free alum for water treatment by several European¹ purification plants suggested that it would be advisable to make determinations of the arsenic content of the filter alum used in this country and particularly of that used in the state of Illinois.

It is well known that products which are manufactured with the aid of commercial sulphuric acid quite generally contain more or less arsenic, depending upon the purity of the acid used. The poisonous character of arsenic compounds, even when present in small amounts, makes it of general interest and importance to have definite knowledge of the presence or absence of arsenic in any substance which enters directly or indirectly into foods or drinks. Sulphuric acid is used in the manufacture of filter alum and it is therefore quite essential, particularly to those who are in public health work, to know whether arsenic in any considerable amounts is being added to drinking water in the process of purification with alum.

We have been unable to find any definite published data relating to the arsenic content of filter alum. Dr. George A. Soper several years ago made an investigation of this problem, and referred to his results while discussing a paper by Mr. E. E. Wall² on "Water Purification at St. Louis, Missouri." Dr. Soper was discussing in par-

¹ Jour. f. Gasbel, 56, 882 (1913).

² Trans. Am. Soc. C. E., 60, 202-9.

ticular the use of sulphate of iron in water treatment and spoke in the following manner:

There is a final point which the speaker hesitates to mention, but, inasmuch as before this society it will probably be taken in the conservative spirit in which it is intended, and may lead to useful inquiries, it may be referred to briefly. It concerns the composition of the sulphate of iron used. . . . What are the impurities in this sulphate? How much arsenic is there in this sulphate? Some years ago the speaker had occasion to examine specimens of sulphate of aluminium from a good many filter plants and found arsenic in nearly all of them. It is true, that usually the arsenic was not present in large quantities, but it was easily discoverable, and in some of the samples it was present in sufficient amount to be of more than passing interest. The arsenic, of course, came from the sulphuric acid used in making the sulphate of aluminium, the sulphuric acid having been produced from pyrites which contained arsenic.

From Dr. Soper's first remark it is evident he realized that, due to the increasing public prejudice against the use of any material containing arsenic or other similar poison, a great injustice might be worked upon both the manufacturer and the plants that use alum for water treatment, by giving widespread publicity to this matter; at least, before all phases of the problem had been thoroughly investigated. The writers, too, are of this same opinion and so have refrained from mentioning the names of any manufacturers whose product have been examined and have also omitted the name of all filter plants outside the state of Illinois.

We have found but one other reference to the arsenic content of water treatment materials. In further discussion of the same paper and relative to sulphate of iron, Mr. E. E. Wall, in reply to Dr. Soper's statements, said:

The writer has a copy of a report . . . in which it is stated that no arsenic was found in any of the samples tested and that the small quantity of arsenic in the sulphuric acid used in cleaning steel is, without doubt, removed in the cleaning tubs in the form of arsenureted hydrogen, thus leaving the liquors from which copperas is made, free from arsenic. Even if there should be a minute quantity of arsenic in the sulphate of iron, it is scarcely possible that this could remain in the water after treatment with the quantity of lime used at St. Louis.

The explanation of the absence of arsenic in sulphate of iron due to its loss as arsine is quite feasible but such is not the case with sulphate of aluminium. Filter alum is made by digesting bauxite with the required amount of sulphuric acid, consequently all or prac-

tically all of the arsenic present in the acid will remain in the finished product.

We have not been able to learn that anything has been done in this country to regulate the amount of arsenic in filter alum. The purification plants, at least in the state of Illinois, have made no effort to obtain an arsenic free article. The manufacturers of alum keep more or less accurate records of the arsenic content of their product. The writers have found only one producer who advertises "arsenic free alum." Neither the government nor any of the states has promulgated legislation regulating this product, although there is a regulation concerning arsenic in other substances entering into foods. The government has set a limit for arsenic in coal tar dyes and in baking powder of one part in 700,000. This very low limit, particularly when it is considered that only relatively small amounts of these substances are used in food preparation, shows that considerable importance is attached to the presence of arsenic and its compounds.

SAMPLES

In order that results might be of greatest value by showing the condition of the alums as they are actually used, as many samples as possible were first obtained directly from the water purification plants in Illinois. Twenty-six plants use alum in treating water. The purpose of the investigation was explained to the managers of each plant. They were asked to coöperate by furnishing a sample of the alum used, together with the name of the manufacturer or dealer supplying the same. Twenty-two of the plants very promptly complied with the request, and in nearly every case expressed decided interest in the subject with a wish to know the results of the investigation.

Owing to expense of transportation practically all of the alum used in Illinois is supplied by three manufacturers. In order to make our study more complete we have extended the scope of our investigations and have secured samples from practically all of the large manufacturers of alum in the country. In some cases the samples came directly from the producer, and in others from the water treatment plants. The specimens of alum were carefully sampled, ground and analyzed in duplicate by the following methods.

METHODS OF ANALYSIS

The method used in obtaining most of the data given is a modified Gutzeit method, developed by Mr. Claude R. Smith³ in his work on coal tar dyes and other food constituents. The results obtained by this method were in several cases checked by the Marsh-Berzelius method⁴ and were found to agree. The Gutzeit method has been investigated by Sanger and Black⁵ and others for quantitative work, and, when proper care is taken in the manipulation, has been found to give satisfactory results. The chief modification proposed by Smith is the use of paper sensitized with mercuric bromide instead of mercuric chloride, which had previously been generally used. The bromide gives more permanent stains and the standards can be kept longer. The method depends upon the formation of a dark orange stain when the generated arsine is brought in contact with the sensitized paper. The apparatus used is essentially as described by Smith. The generator is a 50 cc. wide mouth Erlenmeyer flask. This is connected with two upright tubes 8 cm. in length and 1 cm. in diameter, the lower containing lead acetate paper and the upper filled with cotton moistened with 5 per cent lead acetate solution. Fitted into the upper tube by means of a rubber stopper is a capillary tube 3 mm. in internal diameter and 12 cm. in length. This capillary is constricted at two joints about $3\frac{1}{2}$ cm. from each end. By this means the sensitized paper is held in the center of the tube thus producing stains of equal length on both sides of the paper. Under uniform conditions, the length of the stain varies with the amount of arsenic present. A series of standard stains prepared from known amounts of arsenic are used for comparison. A convenient series is made from 2, 5, 7.5, 10 and 15 micromilligrams. The amount of arsenic in the weight of alum taken is determined by matching the stain it produces with the standards; it is then a matter of simple calculation to determine the percentage arsenic content or the parts per million of arsenic. A one gram sample will contain as many parts per million of arsenic as there are micromilligrams of stain obtained. For example, if one gram of alum produces a stain which matches the 5 micromilligram standard stain, then that alum contains 5 parts per million. One part per million

³ U. S. Dept. Agr., Bur. of Chem., Circular No. 102.

⁴ U. S. Dept. Agr., Bur. of Chem., Circular No. 99.

⁵ J. Soc. Chem. Ind., 26, 1115 (1907).

is equivalent to 0.0001 of one per cent. A stain representing between 5 and 25 micromilligrams gives the most satisfactory results. A stain between these limits can be obtained by varying the weight of alum used.

For the analysis of alum containing more than 30 parts per million As_2O_3 , another method proposed by Smith, was used. The generated arsine is passed into mercuric chloride solution (10 cc. of 5 per cent HgCl_2 diluted to 100 cc.). According to Smith probably several different arsenides of mercury and some free arsenic are formed. These are oxidized by the excess of mercuric chloride, slowly in the cold and rapidly on heating, forming arsenous acid and mercurous chloride. The mercurous chloride can be filtered off and weighed and the arsenous acid in the filtrate determined by titration with iodine. In this way checks are obtained in the one determination. The equation used for the calculation of arsenic from the weight of mercurous chloride obtained is:



Thus $1\text{As}_2\text{O}_3$ is equivalent to 12HgCl .

As an alternative the conglomerate precipitate can be titrated by means of iodine. Sufficient potassium iodide is added to form the soluble double potassium mercuric iodide and then an excess of standard iodine solution. When all the precipitate has gone into solution the excess iodine is titrated with standard thiosulphate. The iodine absorption represents the oxidation of arsine to arsenic acid in which 1As is equivalent to 8I .

As usual all reagents used were tested to prove their freedom from arsenic.

DETERMINATION OF ARSENIC

Five grams of finely ground alum are dissolved in the generating flask in 30 cc. sulphuric acid (1-4) with the aid of heat. Four or five drops of a 40 per cent solution of stannous chloride in concentrated hydrochloric acid are added and the solution cooled. Four or five grams of arsenic free moss zinc are now added and the lead acetate tubes and capillary containing the sensitized strip are connected. The evolution of gas is allowed to proceed for at least one hour. The stain, after drying, is then compared with the standards. A steady, brisk but not violent evolution of gas should be maintained. This can be regulated by varying the acidity, volume of solution, amount of zinc and temperature. After a little experience very

uniform results can be obtained. In the determination of larger amounts of arsenic it is necessary to allow the evolution of gas to proceed for two or three hours.

The sensitized paper is made from heavy, close-textured drafting paper, cut into strips 2.5 mm. by 12 cm. These strips are soaked for an hour in a 5 per cent alcoholic solution of mercuric bromide. The excess solution is squeezed off and the strips allowed to dry.

The results from the samples obtained from the Illinois purification plants are given in Table I, those from outside the state in

TABLE I

Arsenic as As_2O_3 in Filler Alums used in Illinois

CITY	ARSENIC AS As_2O_3		GALLONS*
	Pts. per mil.	Per cent	
Cairo.....	1.6	0.00016	3213
Carlinville.....	1.8	0.00018	2856
Charleston.....	1.2	0.00012	4283
Chicago and Rogers Park.....	1.4	0.00014	3671
E. St. Louis and Granite City.....	0.8	0.00008	6425
Decatur.....	1.4	0.00014	3671
Elgin.....	1.6	0.00016	3213
Evanston.....	1.4	0.00014	3671
Ft. Sheridan.....	1.2	0.00012	4283
Hamilton.....	1.4	0.00014	3671
Kankakee.....	0.8	0.00008	6425
Kenilworth.....	1.4	0.00014	3671
Lawrenceville.....	3.0	0.00030	1713
Macomb.....	1.6	0.00016	3213
Moline.....	1.0	0.00010	5140
Mt. Carmel.....	2.0	0.00020	2570
Mt. Vernon.....	1.2	0.00012	4283
Pana.....	1.2	0.00012	4283
Quincy**.....	1.0	0.00010	5140
Quincy**.....	4.0	0.00040	1285
Rock Island.....	2.0	0.00020	2570
Rock Island Arsenal**.....	1.6	0.00016	3213
Rock Island Arsenal**.....	1.0	0.00010	5140
Streator.....	3.4	0.00034	1512

* Gallons of water containing a minimum medicinal dose of 2 mgm. when the water is treated with 6 grains of alum per gallon, provided that all the arsenic remains in solution.

** Two samples from different manufacturers.

Table II. In all cases the arsenic is recorded as arsenic trioxide, As_2O_3 . Twenty-four samples from Illinois plants and seventeen from sources outside the state were analyzed.

The results obtained by analyzing alum used in Illinois clearly show that arsenic in exceedingly small amounts is always present in filter alums. We find a minimum of 0.8 part per million (0.00008 per cent) and a maximum of 4.0 parts per million (0.0004 per cent) of arsenic as As_2O_3 in the alum used by Illinois water purification plants. If a water were treated with alum containing the maximum amount of arsenic found, at a rate of 6 grains of alum per gallon, an amount which is very seldom exceeded, and if all the arsenic were soluble and remained in the filtered water, since arsenic is not a cumulative poison, a person must drink 1285 gallons of the treated water at one time to obtain a medicinal dose of 2 mgms. From this it is readily seen that the arsenic content of filter alum used in Illinois is of no significance.

TABLE II

Arsenic in Filter Alum Obtained from Sources Outside the State of Illinois

SAMPLE NO.	ARSENIC AS As_2O_3		GALLON*
	Pts. per mil.	Per cent	
1	0.5	0.00005	10280.0
2	1.2	0.00012	4283.0
3	1.2	0.00012	4283.0
4	1.4	0.00014	3671.0
5	2.6	0.00026	1977.0
6	2.6	0.00026	1977.0
7	4.0	0.0004	1285.0
8	4.0	0.0004	1285.0
9	5.0	0.0005	1028.0
10	20.0	0.0020	257.0
11	27.0	0.0027	190.0
12	31.0	0.0031	166.0
13	49.0	0.0049	105.0
14	280.0	0.0280	18.0
15	941.0	0.0941	5.5
16**	1240.0	0.124	4.0
17	1240.0	0.124	4.0

* Gallons of water containing a minimum medicinal dose of 2 mgm. when the water is treated with 6 grains of alum per gallon, provided that all the arsenic remains in solution.

** Nos. 16 and 17 were obtained from the same plant and are probably from the same lot of alum.

The samples obtained from sources outside the state showed a wider range in arsenic content. In one case there was 0.5 part per million (0.00005 per cent), and in nine cases there was more than in the highest Illinois sample, the maximum being 1240 parts per million of arsenic as As_2O_3 (0.124 per cent).

If a water were treated with alum containing 1240 parts per million As_2O_3 , at the rate of 6 grains per gallon and provided all the arsenic remained in solution, 0.13 part per million of arsenic as As_2O_3 would be added and a medicinal dose of 2 mgm. would be contained in four gallons. This would be quite an appreciable amount and is more than should be added in water purification. However, owing to the insolubility of the arsenites and arsenates of calcium, magnesium, aluminium and iron, a large part of the arsenic would be removed with the precipitated aluminium hydrate. To determine the extent of this removal, if any, several experiments were carried out.

Two liters of water were treated at the rate of 6 grains per gallon with an alum containing 941 parts per million of As_2O_3 . By this treatment 188 micromilligrams of As_2O_3 were added. Forty micromilligrams of As_2O_3 were recovered from the filtered water and 144 from the sludge. Thus only 22 per cent of the arsenic remained in solution.

Some water was treated at the rate of 20 grains per gallon with an alum containing 1240 parts per million of As_2O_3 . Only 12 per cent remained in solution.

A sample of filtered water was obtained from the filtration plant using this latter alum. It had been treated at the rate of 200 pounds of alum per million gallons or at the rate of 1.4 grains per gallon. From this water only 7 per cent of the arsenic originally added was recovered from the solution. Thus a removal of 93 per cent of the arsenic was effected by the purification process.

CONCLUSION

Filter alum used by water purification plants in Illinois does not contain a significant amount of arsenic. Some filter alum used elsewhere contains a much larger amount of arsenic, but since at least 75 per cent of the arsenic added in the treatment of water with alum is removed with the precipitated aluminium hydrate, there is a strong probability that in no case a sufficient quantity of arsenic would be added to the filtered water to have therapeutic

significance. However, since alum containing an insignificant amount of As_2O_3 can be readily obtained, the manufacturers should make an effort to keep the arsenic content of their product at a minimum and water works officials should demand an article practically free from arsenic.

We wish to express our appreciation of the assistance rendered by the manufacturers and water works officials who furnished us samples for examination.

DISCUSSION

MR. JAMES M. CAIRD: This was a very interesting paper which has just been presented by Dr. Bartow, and the large amount of data is of great value. The speaker does not like the use of the word alum, when really sulphate of alumina is meant. The general public has an awful horror of that word *alum*. Bringing up the subject of arsenic; the medical profession is very strict about the use of any water supply where alum or sulphate of alumina is used for purification, and now to think that Dr. Bartow is using alumina which contains arsenic: why, they are likely to go up in the air a little farther. Within two months a letter was received from an official of a state department of health, in which he says he would never be convinced that there was not some sulphate of alumina in the filtered water, although tests failed to show it. Now if that is the feeling in some of the health departments, if they think that there is arsenic too, what will they do about it?

The question of contaminating drinking water by using, for its purification, sulphate of alumina containing arsenic has often been discussed, and it has invariably been found that, even if the sulphate of alumina used contained determinable quantities of arsenic, no trace of arsenic was found in the filtered water. First, because part or all of the arsenic is precipitated with the ferric or alumina hydroxide formed in the purification process and filtered off. Second, because the small amount of sulphate of alumina used per gallon of water would bring down the arsenic content in the water to indeterminable traces, even if no arsenic was removed by the purification process. The Pharmacopeia of the United States requires that a chemical to be pure may contain not over ten parts per million of As_2O_3 .

It is permissible to refer to the Royal British Committee appointed to investigate the so-called "Manchester beer scare" in 1901. This

committee gave the result of their investigations at the meeting of the London session of the Society of Chemical Industry in January, 1902. Their recommendation was chiefly on the method of testing for minute quantities of arsenic, and the discussion following was more or less of a farce. One member of the committee, a medical man, Dr. James Edmunds, doubted whether they had reached the real cause of the illness and death in the Manchester epidemic. He had been in the habit of prescribing arsenic and giving two or three milligrams per dose three times a day for a good many weeks, and had never known a case of arsenical neuritis to result. Most of the cases were proved to be alcoholic neuritis, not arsenical neuritis. One of the patients, who was confined to bed for three months with what was supposed to be arsenical neuritis, had been a total abstainer all his life, so that beer could hardly be blamed for his case. In short it has never been positively proven that the arsenic found in Manchester beer was the cause of the epidemic of neuritis in Manchester. Presumably that is why it is known as the "Manchester beer scare."

Arsenic is found so frequently everywhere in nature that it is impossible that natural water should not contain more arsenic than would ever be put in by using sulphate of alumina for its purification. All clays, ochres, iron ores, etc., contain arsenic, and all the waters from the most famous mineral springs, where people go for their health, contain arsenic in considerable quantities. Vichy, two parts per million; Carlsbad, varying from determinable traces to twenty-five parts per million. The late Sir Edward Franklin positively found arsenic in the atmosphere of London. Arsenic is found in the waters of the Rhine, Nile and in the Delaware river; in many vegetables, such as lettuce, beets, etc., but this must be considered dangerous ground, as all the acid phosphates used as manure contain large quantities of arsenic.

MR. CHARLES A. JENNINGS: The speaker had a practical application of this paper by Dr. Bartow, just a very short time ago. One of the packing firms in Chicago had a shipment of alum turned down by the government because it contained 125 p.p.m. of As_2O_3 . As a result they were willing to sell that alum for about 15 cents per hundred pounds less than the regular price we were paying for alum.

MR. JAMES M. CAIRD: A case in the speaker's own family might be of interest; in this instance "arsenora" a compound of arsenic and gold has been used for the past fifteen years. The dose reaches, at times, as high as sixty drops per day before producing any trouble to the eyes.

DR. EDWARD BARTOW: We did analyze the water that had been treated with the alum containing arsenic, and actually found about nine per cent of the arsenic remaining in the filtered water. That was an actual test that we made.

MR. JAMES M. CAIRD: Did you try the raw water too, and could not find any there?

DR. EDWARD BARTOW: There was no arsenic in the raw water.

MR. A. ELLIOTT KIMBERLEY: Are there any cases on record suggesting arsenical poison through water?

DR. EDWARD BARTOW: Not to the author's knowledge.

MR. PHILIP BURGESS: Is there any germicidal action of the arsenic?

MR. WILSON MONFORT: Regarding that, the speaker has been watching with a good deal of interest the development of a mold in a tenth normal alkaline arsenious acid solution for some time, so arsenic is not necessarily fatal to vegetable organisms.

METHODS OF WASHING SLOW SAND FILTERS

BY JOHN GAUB¹

In late years various processes for cleaning the sand of a filter bed have been advanced; some partly destroying and others exterminating the filter film on the bed. These ideas have in some cases caused trouble and in others only repair. There is no doubt that the rough treatment of the sand surface, a penetration of organic matter and filth into the bed cause deep clogging, which prevents the yield of water, and causes the beds to become inefficient.

Attempts to reduce the work of cleaning filters are commendable, because scraping, sand handling and raking are the items of greatest expense in slow-sand filter maintenance; hence it is the endeavor of the writer to show what attempts along this line have been made, both from an economical and efficient standpoint.

In this country it is bad economy to discard the sand scraped from the filters, for the expense attached to the preparation of new sand is very high, since it must be washed free from clay and screened before it is ready to be placed in the filter. Yet in Osaka, Japan, the sand is dredged from the Yodo river opposite the water works, and made suitable for the beds and placed therein for about 65 cents per cubic yard, a figure so low that no attempt is made to recover by washing the sand scraped from the filters.

In handling the sand for slow sand filters several methods have been tried, each giving results at a small cost in some places, while in others the contrary is true. The writer, therefore, compiled tables from plants using these methods, together with their costs. However, before delving into the methods as practiced at the various plants, a brief description of the methods commonly used will not be out of place.

THE BROOKLYN METHOD

This method was first used in 1905 at the Hempstead filters, at Rockville Center, Long Island, and consists in lowering the water to

¹Supt. Filtration Plant, Washington, D. C.

a few inches in depth above the surface of the sand on the filter. Unfiltered water is taken from an adjacent filter in service and run in a stream over the bed to the outlet drain, a depth of about 1 inch of flowing water being maintained over the section to be cleaned. Men in boots agitate the surface of the sand with long-toothed garden rakes, thus stirring the dirt from the sand and having it carried away to the drain. The filter is generally cleaned in sections by cutting off the part undergoing cleaning from the rest of the filter by boards set on edge and driven down into the sand, forming a miniature flume with board sides. After cleaning, the boards are removed to a new position. When the filter is clean, filtration is resumed. This method is somewhat costly, in that about 1 per cent of wash water is used. In cases of emergency it has given good results. At Philadelphia, it is reported that with 14 men and a foreman a three-quarter acre bed can be cleaned in eight hours and that such a bed will be out about nineteen hours a month.

SAND WASHING MACHINES

These machines are recent additions to the washing apparatus used in slow sand filters. They began their existence about 1909 when the Washington plant adopted the "ejector washer" system. Previous to this time the dirty sand, after being scraped, was shoveled into portable ejectors on the beds, to be thence forced by water pressure through pipes to stationary sand washers. After being washed, the sand was discharged into storage bins, from which carts driven underneath may be loaded, and the sand carried to the filter and placed.

THE BLAISDELL MACHINE

This machine may be described as a traveling crane spanning a filter unit and supporting a watertight rectangular chamber containing the machinery necessary, and provided with means for lowering this chamber to the sand surface and traveling over the filter while the process of washing is in progress. The chamber wherein the washing takes place may be raised so as to clear the rim of the filter and thereby remove the machine to another filter.

About 2 inches above the sand or bottom of the sand chamber there is a plate or diaphragm dividing the washing chamber into two compartments placed above each other; the lower, used as a suction chamber from which the dirty wash water is withdrawn, contains

stirrer wheels mounted on vertical shafts; the upper contains the driving mechanism for the stirrer wheels and also the pressure and suction pumps.

From the stirrer wheels, in the lower chamber, supported on vertical shafts above the sand, numerous teeth project into the sand to any desired depth. The teeth are hollow and perforated in order to create a water jet action from the supply delivered by the pressure pump. The water for the pump is taken from the water on the filter, while at the same time a suction pump joined to the top chamber withdraws not only all the water the pressure pumps supply through the perforated teeth, but also an additional amount from the filtered water in the sand. In operation, the teeth scour the sand, while the wash water by its jet action drives the dirt into the suction chamber and the clear water stored in the filter bed is drawn into the washing zone by the excess suction over the pressure supply, and the wash water is pumped from the supply before the machine passes a given point. The chamber is placed close to the surface of the sand by shoes extending in advance and to the rear of the front end back plate, while the side plates cut down into the filter sand.

The pressure water rises through the disturbed sand zone and is displaced by the inrush of clear water, the upward current of which occurs well toward the center of disturbance created by the teeth and covered by the suction chamber. The sand is forced apart by the teeth, and as they return the strong upward current of wash water causes a temporary suspension and churning action within the suction chamber. During this time the dirt and light particles are brought to the surface and withdrawn with the wash water. The sand in suspension settles after the violent upheast subsides, so that when the sand comes to rest it is uniformly water packed and free from air. The wash water from the machine is discharged to a gutter formed generally in the party wall between filter units. The wash water may be so controlled that sizing may be done by working all very fine sand to the surface and removing that which is too fine from the filter. This sizing is done by increasing the duty of the pressure and suction pumps so as to secure a downward velocity by which to hold the sand in suspension.

All of the operations of this machine are controlled by separate motors which are operated from a platform. Generally there are six motors mounted on the machine with variable speed controllers. With this machine it is possible to wash a bed of an acre in about

twelve hours, and in about fifteen hours the bed can be in service, allowing three hours for closing valves, etc.

THE NICHOLS WASHER

This machine has been in use since 1910. It enables the operator to wash the sand on the filter without removing it from the bed, thereby saving not only in wash water, but also in labor, etc.; in other words the total saving being about 35 per cent of what it would cost to use the old method of scraping, removing, washing and replacing the sand. Briefly, the machine consists of an inverted cylinder inside a closed jacket. The dirty sand is fed into ejectors in the usual way, and the wash water with the sand and dirt passes through the machine. The water strikes the side of the cylinder, and the sand being heavy drops to the bottom and passes through a nozzle on to the filter. About 2 per cent of fine sand passes out with the water and dirt to the court where it generally settles while the débris goes to the sewer. It has been shown at some places that it is possible to clean 10 cubic yards per hour using 1200 gallons of water per cubic yard, whereas by the old method 2800 gallons of water were used. Again, at some places this machine has been modified, in that several sprays of water play on the sand within the machine; also more baffles have been added, thus causing a better wash for the sand.

METHODS OF WASHING SAND AT DIFFERENT PLANTS

Washington, D. C.

Until 1909 the filters were scraped and the sand piled, and then removed by ejector and one or more lengths of hose to the sand washers. After the sand was washed, it was discharged into storage bins from which carts were loaded and the sand brought to the desired place on top of the bed, and there dumped and spread evenly. After 1909 the hydraulic method of replacing was used, whereby an ejector is placed underneath the outlet gate in the storage bin, and the sand is carried in a reverse direction from the bin through piping and one or more lengths of hose to the bed. This process has decreased the cost of resanding and has proved very satisfactory in every way. This method has been used or tried in several places with more or less good results. At Washington the filters are resanded as follows: the filters are filled with water to the desired depth

of the sand layer. The outlet end of the hose is joined to a 3 inch pipe supported on a boat, and the sand is discharged through the pipe at the point required. Generally work is begun at the far end of the filter, and is gradually filled by swinging the boat from side to side and backing it by degrees to the front end. By this method the sand has no tendency to separate into different sizes, if the discharge has a slope of about 40 to 45 degrees from the horizontal. By this position of the discharge pipe the old surface of the sand is cut and moved ahead with the new sand, thus breaking up the possibility of forming a mud layer between the old and new layers. The following is the average cost of scraping, ejecting, washing, transporting, replacing and raking.

SCRAPING			RAKING		
Per cu. yd.	Per M. G.	Per acre	Per cu. yd.	Per M. G.	Per acre
30.096	\$0.07	\$16.08	\$0.042	\$0.03	\$6.64
EJECTING, WASHING AND TRANSPORTING			REPLACING		
.168	.11	28.32	.08	.06	

Sand Ejectors. The movable ejector is novel for two reasons: (a) The water for making the sand into suspension is brought up from the bottom and rises as the sand is shoveled into it, thus producing a mixture having more sand in proportion to water. (b) The discharge ends of the ejector are made like the discharge end of a Venturi meter, with a flat batter. The economy herein lies in the fact that use is made of the velocity head in the throat, which is lost with the batter made in the usual way. For a more detailed description of these ejectors and the tests whereby they were tested, the reader is referred to Vol. 57, 1906, of the *Transactions of the American Society of Civil Engineers*.

Sand Washers. The sand washer used here differs from the usual type of washer, in that the mixed sand and water fall into the hopper. From the hopper there is a free opening to a chamber formed by a globe casting. A second jet of water enters this chamber near the bottom, and is carried into the throat of the ejector with the sand as it leaves the hopper. The sand settles through the water into the chamber and is separated from all dirty water which came

with it. The hopper usually used dilutes the dirty water in the sand, but the one devised at Washington makes a complete separation.

Toronto, Canada

Sand is washed by a portable washer. After being scraped in piles it is put into an ejector box from which it is carried to the washer. In the washer it passes through sprays of clear water, and by the action of baffles, falls to the bottom, where a strong spray drives it out through a hose, which distributes the clean sand on the filter. The wash water used is about $\frac{1}{3}$ per cent of the net yield of the filter. The wash water passes up to the top of the washer, then down to a 3-inch drain which connects with a 36-inch drain. The cost per cubic yard of sand, washed and replaced, including washer pump, handling sand, repairs, etc., is about \$0.61.

Denver, Colorado

The sand is conveyed from the filters to the washer through an ejector and sand line of hose at a pressure of about 150 pounds. In this plant the ejector method of replacing was tried, but owing to stratification, was abandoned. The cause of stratification probably was a too high uniformity coefficient of the sand as it left the washer. The sand is replaced from dump cars, the cars being loaded by hand, hauled to the side of the bed by horse power, dumped, reloaded into side dump cars, pushed by hand to the place desired, dumped and spread. This is very costly, but owing to the thoroughness of mixing, it appears to be the best in the end. The total cost per cubic yard for cleaning and washing the sand on a bed is about \$0.73.

New Haven, Connecticut

Here the water is drawn off and the sand piled, and wheeled to the hopper and carried to the washer by hydraulic means. From the washer the sand goes to a receiver in the bed having the lowest depth of sand, in which it is spread around and allowed to accumulate until the maximum depth of 40 inches is reached, when the apparatus is put into the next bed having the least depth. By this process about 5 cubic yards per hour can be washed, using about fifteen volumes of water to one of sand. The cost of cleaning per acre is about \$75 not including the cost of water. About 60 cubic yards of sand are removed per cleaning, making the cost per cubic yard about \$0.43.

Albany, New York

Up to 1910 the sand was washed and handled by the ejector method, but replaced by hand. In 1910 the Nichols machine was introduced and the cost of cleaning and replacing was reduced 44 per cent. However, there has been some trouble with the beds in this plant due to the formation of two filter-films caused by putting the new sand on the beds after forking the sand that remained there. The procedure of forking at the junction of ejected sand caused this film to increase until the turbidity of the sand ran 3-5000 and the output of the eight beds fell to 10 million gallons per day. However, the cost since 1910 to 1914 and 1899 to 1900 is as follows:

July 1899-1900

	<i>per mil. gal.</i>
Scraping.....	\$0.25
Wheeling out sand.....	.50
Washing sand.....	.59
Refilling.....	.39

In 1910 a comparison was made between the Nichols machine and the box-sand washer with the following results:

Cost per cubic yard by box-sand washer.....	\$0.409
Cost per cubic yard by Nichols.....	.226

Since 1912 and including 1914, the following is an average cost per million gallons.

Scraping.....	\$0.07
Ejecting.....	.12
Washing and replacing.....	.16
Reforking beds.....	.01
Total.....	<u>.36</u>

Lawrence, Massachusetts

The sand is ejected to a set of three hoppers outside the bed. The sand from the last hopper is ejected to a large box having a weir which holds back the sand and permits an overflow of waste water. The sand is then shovelled out from the box down one of the ventilation holes for distribution on the bed. The cost per cubic yard is about 25 cents. It is claimed at this plant that the wheeling of the sand to the desired place and casting insures proper mixing, while the use of water pressure causes stratification due to the uniformity coefficient of the sand.

Pittsburgh, Pennsylvania

This plant has tried scraping, raking and washing machines. However, it appears that they are somewhat expensive, since the last four years, 1911-14, the hydraulic method was used and adopted. In the reports this method is known as the "Washington Method." The following summary gives an idea of the average cost.

SCRAPING			EJECTING	
Per cu. yd.	Per M. G.	Per acre	Per cu. yd.	Per M. G.
\$0.175	\$0.314	\$25.42	\$0.254	\$0.450

RAKING			RESTORING SAND	
Per cu. yd.	Per M. G.	Per acre	Per cu. yd.	Per M. G.
\$0.061	\$0.064	\$8.90	\$0.087	\$0.147

WASHING AND TRANSPORTING				
.120	.213	17.52		

Philadelphia, Pennsylvania

At Torresdale, the sand washing pumps had not been installed at the time of starting the plant, so another method of washing was resorted to, viz: the Brooklyn, as described above. This method was used until March, 1908, with little success, due to the sediment, organic matter, and micro-organisms forming a paste-like layer extending about 4 inches in depth. The consistency of the filter film was so at times that it could be removed in cakes. The runs were short and after about 100 million gallons had been filtered spading was tried in order to get the water through the filters. By this process, the surface of the filter was gone over with a spade and thrust down to a depth of 8 inches, and worked back and forth to break the layer. This caused an increased drop in efficiency with little assistance in length of runs. Next, the piling method whereby the sand is piled, waiting to be washed at some future time, was adopted, and it gave good results.

About 1909 Mr. Nichols designed a machine which today is used very much, by which it is possible to save 25 cents per cubic yard

in sand handling. The advantage of this machine is that the thickness of the filter is not reduced while the danger of breaking through is decreased, and the efficiency not affected by the change in the rate of each filter. At this plant raking is practiced to the extent of two or three times per scraping. The following is a summary of the costs of the various methods used at Philadelphia:

REMOVAL		PILING	BROOKLYN	RESANDING
Per M. G.	Per cu. yd.	Per M. G.	Per M. G.	Per cu. yd.
\$1.46	\$0.43	\$0.58	\$1.68	\$0.26
NICHOLS		RAKING	SPADING	
1.22	.41	.12	.38	

Springfield, Massachusetts

The methods used here are practically similar to those used at Washington, D. C. The following is a summary of the costs:

	M. G.
Cleaning.....	\$0.36
Resanding.....	.17
Raking.....	.09

Wilmington, Delaware

At this plant a very good example of the Blaisdell machine is seen. The machine is used for raking and washing the sand on the beds. It was expected that the cost of sand washing, etc., would not be greater than one dollar per million gallons. However, since the plant requires intelligent superintendence at all times, and skilled mechanics for operating the washing machine, and notwithstanding that the machine is idle about 70 per cent of the available working time, the cost has been a little over the expected cost. The following summary gives an idea of the requirements of the machine together with the costs.

Average kw. per bed.....	115
Cost of kw. per bed.....	\$3.45
Total cost per M.G.....	1.23

The total cost per million gallons is an approximate sum, but the other figures are averages for the years 1911-14.

YIELDS

Having considered the methods for washing the sand of the various slow sand filters, it now becomes our duty to consider the different methods as to yields.

Philadelphia, Pa. (Torresdale)

1907-12 (SUMMARY)

	Yield, million gallons				Days run		
	max.	min.	av.	rate	max.	min.	av.
Brooklyn.....	67	4	19	1.8	49	6	14
Removal.....	379	10	74	3.6	105	4	27
Nichols.....	569	30	150	4.4	148	11	45
Rake 1.....	280	3	85	4.7	75	2	24
Rake 2.....	120	17	52	4.6	31	6	15
Rake 3.....	73	17	41	3.9	24	5	14
Piling.....	167	3	35	2.6	19	2	18
Spading.....	90	11	51	4.5	22	4	15

Washington, D. C.

	AV. NUMBER OF RUNS ENDING		DURATION IN DAYS (AV.)		AV. MILLION GALLONS FILTERED		
1905-10	143.4		66		170.13		
	Rake	Scrape	Rake	Scrape	Rake	Scrape	Total
1910-14	75.5	84.2	56	68.5	119.87	150.24	270.11

Springfield, Mass.

1913	23	22	44	48	79.08	98.29	177.37
1914	24	26	40	44	77.15	84.64	161.79

Wilmington, Del.

	PER CENT TIME OUT	DAYS OPERATED PER WASH	YIELD PER WASH	YIELD PER RUN
			M. G.	M. G.
1911-12	2.10	13.4	14.127	24.372
1912-13	3.0	20.5	9.817	39.877
1913-14	2.3	23.8	7.133	45.648

From these tables it will be seen that each method has its advantages and disadvantages. The Blaisdell machine is very economical in that the time in which a filter is out is practically at a minimum; however, the days in which the filter is operated after the wash are somewhat at a minimum also. As for total yields the processes as practiced at Washington and Torresdale appear to show up better. However, from a standpoint of duration in days the Washington methods are the best and cheapest.

CONCLUSIONS

From the experiences at the various plants cited it is seen that much improvement in sand handling has been in progress, especially in building machines.

The cost of cleaning a filter by machine has not been reduced below that for cleaning and replacing sand by the improved hydraulic processes.

The uniformity coefficient of the sand is an important factor to consider when hydraulic processes are used.

The hydraulic processes as practiced at Washington and Springfield are the cheapest and most economical.

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ASSESSING COSTS OF EXTENSIONS IN A MUNICIPALLY OWNED PLANT

BY D. A. REED¹

It has been generally conceded that certain civic improvements or conveniences constructed or furnished by a municipality may not be wholly paid for by general taxation, but may be assessed as special benefits against abutting property. This assessment may cover the costs in whole, or in part, but the principle is recognized that a local improvement of any nature must of necessity carry with it some direct benefit to the abutting property. It is also true that no improvement can be made without some benefit to the municipality at large. With improvements of this nature we may properly class sewers, street improvements of all kinds, water works, gas plants, and possibly other utilities.

An improvement of any kind which is largely local in nature, that is, which from the nature of its construction is largely an accommodation to the abutting property only, is found in lateral sewers and water mains of minimum capacities supplying or serving local properties only, and which do not provide capacities in excess of local requirements, and which are not indispensable for serving more distant territory.

Street improvements, including pavements, curbs, gutters and culverts, trunk sewers and the larger sizes of mains in the distribution of a water or gas supply, serve to accommodate a less restricted area and cannot be considered as strictly local in their nature. A pavement for instance, on one street alone, might well be considered as a benefit to some extent of all the property within the city limits or even outside of the city limits, although its greatest benefit would be to the property adjacent, a sewer, however, might be entirely local so far as its benefits are concerned and be of no value whatever to any other property.

The logical method for assessing the cost of any improvement, the product of any utility, or the benefits from any service rendered, is

¹ Manager Water and Light Department, Duluth, Minn.

upon the interests directly benefited. In private business where one interest often benefits largely from the enterprise of another, there is no practicable method of applying this rule unless they are customers or purchasers of the products of that utility, and even then the costs are often disproportionate to the service rendered on account of the escape of such interests from the contribution as do not purchase directly the products of that enterprise.

A city owned utility usually has the power to assess certain benefits, whether the party interested chooses to be a consumer or not. Applying this fact to sewers and water mains the proper method would be to assess the costs of construction, or in other words, the capital investment, against the property that it is possible to serve. The costs of operation, however, should be levied against the parties purchasing the output or using the service.

Sewers, after they have been constructed and the costs having been met by all the property owners served, regardless of whether they are connected or not, should be operated at the expense of those only who use or are connected with it. The operating costs, however, are relatively small and are not usually assessed but are paid out of the general fund supported by general taxation. In a street improvement it would be manifestly impracticable to assess costs of operation against those served or who use the utility; in a manner, however, this is accomplished by means of a wheelage tax, the receipts of which are applied to operating expenses.

In the case of a municipal water supply, these matters seem to be much easier of solution and it seems quite practicable to assess costs of construction directly upon the property susceptible of being served, and to assess the operating costs directly upon the customers or patrons of the utility, in proportion to the quantity of water consumed. This condition it must be observed is not met entirely by a rate charged upon a demand and output basis such as is in effect in New Orleans, for the reason that the demand charge does not extend to vacant property.

To those who believe that vacant property should not escape taxation for any improvement that directly enhances its value, this fact will appeal. It would also seem to be a fair check or restraint upon interests that invest in idle property with a view of gain which results largely from the activities of others and in which its existence directly increases the cost of every utility that passes the premises.

It is assumed that a municipal water plant should be self-sustain-

ing in every sense of the word. It should neither give nor receive any benefit or consideration of any kind from the taxpayer, the city or the individual.

A water main in which the size is in excess of the minimum may be classified as serving two purposes, the service to the property directly abutting and the service to properties located more distantly from the source of supply. In the first instance, for the purpose of this discussion, a 6-inch service may be considered as sufficient, and for all sizes in excess of 6 inches, for the additional service to those more distant. Assessments against abutting property for the 6-inch main are easily applied. For costs of mains in excess of this size the only practicable way appears to consider the additional cost as a part of the general distribution system, the expense of which has to be absorbed by the utility and included in the consumers' rates chargeable as operating costs. The direct assessment to the abutting property for the 6-inch main, this size being used as a matter of convenience, may be assessed against the abutting property by means of either of two methods. First, in the total, on the completion of the work, which is paid by one assessment. Second, the principal being furnished from the funds of the utility a percentage may be assessed annually against the property to cover interest and sinking fund upon the investment. After a term of years the percentage assessment will have returned enough money to the utility to cover the principal as well as interest upon the investment. Ordinarily the vacant property thus assessed should continue to pay the assessment for the full term of years necessary to wipe out the original costs. Improved property, using water and paying for it upon meter rates would be entitled to some credit or rebate on account of these rates, especially if the rates are based upon capital investment expense as well as operating costs upon the entire plant. Assuming for the purpose of illustration that one-half of the water rates are to cover interest and sinking fund expense, and that the balance is to cover operating costs including depreciation, it will be found necessary to credit one-half of the customer's water rates against his assessment. This credit will ordinarily retire the annual percentage assessment upon improved property, unless the cost of constructing the extension was large and the consumer's consumption was low. If his consumption is considerably more than necessary to wipe out his individual assessment, the surplus, of course, should be applied pro rata to lessen the tax upon the vacant prop-

erty. It is quite possible for the consumption on an extension to increase to such an extent that the overplus of credits will be sufficient to retire all the assessment against the vacant property upon that particular extension, in which case, having reached that point, all assessments should be discontinued as the customers are carrying the entire expense of the extension, including capital investment as well as operating costs. This even may be accomplished at the end of one year or two years or possibly ten or fifteen years, depending upon the rate of the percentage assessment against the property, the interest and sinking fund factor in the rates charged for the water, and the amount of the consumption upon the extension.

It is also quite possible an extension may be made where there is no consumption for the first year. In this case all the property pays the percentage assessment with no credits and the utility receives the exact amount necessary to pay interest and sinking fund charges.

The method employed at Duluth, Minnesota, in which a gas utility is also operated in connection with the water system, the pipes being laid in the same trench, has been to assess annually against the abutting property, 8 per cent of the total cost of each extension as represented by a 4-inch gas and a 6-inch water main, it having been established that sizes in excess of these dimensions would be more or less of a general benefit to all customers and property and for the strengthening of the system to benefit other customers outside of those served by that particular extension. The proportion of charges against the abutting property has been based upon 5 per cent for interest and 3 per cent for sinking fund assessed annually for a period of fifteen years, 3 per cent contribution to a 4 per cent sinking fund however will not retire the principal short of 22 years, but for various reasons it has been considered advisable to limit the duration of annual assessments to a fifteen-year term. A special discount of 25 per cent is allowed to those paying the total amount in one payment. These assessments are made according to the frontage of the lot, without reference to its depth. However, the frontage of the lot is not considered necessarily as being the side abutting the street upon which the extension is made. It may lie parallel to the mains and front on another street. It is assessed the same as other lots of the same frontage dimension. Subsequently if mains are laid in front of the short side no assessment is made therefor on this particular lot, which can of course, receive no benefit from a second extension. Against this assessment is credited one-half of the water

and one-third of the gas rates paid by the occupant of the premises, it being estimated that these proportions are necessary factors in a rate that will yield the proper amount of revenues for maintaining and operating the plant.

The principles and results involved in the methods as outlined above seem to be as follows:

1. All charges whether of installation or of operation against property or a customer are based upon actual cost.

2. Costs of distributing systems are ordinarily borne by abutting property except when the consumption is sufficiently large to assume the whole or part of this expense when the charge is gradually transferred to the customer.

3. The customer bears operating costs and such installation charges as cover reservoirs, pumping machinery, stations, intakes and the larger distributing mains.

4. As the municipal plant increases in size and in the amount of its revenues, its percentage of indebtedness will gradually decrease, the proportion of interest and sinking fund in the rates charged for water will decrease until eventually, when no indebtedness exists, this factor will become zero and there will be no credits against the assessments. They will have to be met in full cash payments or the consumer may discount the entire amount of his individual assessment by paying cash, taking advantage of the 25 per cent discount.

5. The percentage plan enables the small property owner who is a consumer to obtain extensions on very easy terms, with practically no additional expense over and above the regular water rates.

6. It seems to be a practicable way for real estate owners to secure extensions of gas and water service in newly platted additions without throwing any of the burden upon the utility or its customers.

7. It furnishes a profitable investment at 8 per cent net for the sinking funds of the department until the time arrives when it will be needed to retire bonds, at which time, if the money or any portion of it cannot be withdrawn, refunding bonds or new bonds in whole or in part may be issued. Eventually, if the rates for service have been correctly established, the time will be reached when its entire indebtedness will be retired. This will be true if depreciation and maintenance have been provided for in the operating expenses as well as interest and sinking fund on the indebtedness.

DISCUSSION

MR. WIRT J. WILLS: The speaker does not suppose there can be any absolute rules for these kinds of extensions and probably it might be well for some of us to tell how it is done in our own towns.

In Memphis, Tennessee, a municipally owned plant, the water board, laid one hundred foot extensions to the houses. Should a subdivision be opened up without any houses on it, the owners of the subdivision have to take advantage of what we call the "water-note plan," which is a note made up like any other note only it says, "payable in rentals from water without interest so many dollars;" for instance, the man that gives this note advances the money and all of the revenues out of that line are credited up to him until all the money that the main cost has been returned to him. In that way probably 40 per cent of the resident district of Memphis has had mains put in and a great many of them are already paid for. Some of them are not quite paid up yet. Of course when it comes under construction the man that advances the money takes all the burden of the scheme. If we put down a main for a man for a subdivision and it is not developed properly and is perhaps sold for a brick-yard, all the burden then comes on him if it is not a success.

MR. JOHN M. DIVEN: Does that apply only to new development, or to all extensions?

MR. WIRT J. WILLS: You know that Memphis is about all extended except newly annexed territory out in different places. One street was opened up by one of the water commissioners, in the heart of the residence section, and he had to put up fourteen hundred and sixty dollars just the same as if he had been any other man; but, except in new territory, there is very little in the suburbs that is not annexed. We find it comparatively satisfactory, people get their money entirely back and it is satisfactory to us.

MR. J. M. DIVEN: That money comes out of the revenue; it is never capitalized?

MR. WIRT J. WILLS: It is simply treated as an advancement of the money, or bills payable.

MR. J. M. DIVEN: It does not appear in your capital account?

MR. WIRT J. WILLS: The money advanced is credited to a separate account known as "water note account" (or bills payable). The main laid is charged to construction the same as all other mains laid are charged.

Twice a year the amount paid for the use of water from said main is returned to the party who advanced it, and charged to "water note account." This money is paid out of a fund derived from the sale of bonds, the same as all construction is.

However, the legal advice on the subject is, in this state, when a water company or municipality makes enough money to pay its interest, to create a sinking fund, pay all its expenses, and the price of water is equitable, any other moneys earned "can be used for construction if necessary."

In this scheme, the man who wants the main at once, simply advances the money without interest, and it is returned to him according to the main's earning capacity.

MR. JOHN M. DIVEN: If all of your construction and extensions were provided for in that way you would have no capital account for the distribution system, and no interest on that part of the construction would appear in the operation cost of the works.

MR. ALEXANDER MILNE: The suggestion of the Secretary is perhaps comparable to the method adopted by a careful individual as to his own house and lot. A municipally owned water works is simply a collective individual interest and if it were necessary to expend any sum within the ability of the finances for renewals or extensions, and it could be done from "savings" from revenue account without further bonding or mortgaging the "collective" property, the effect would be equally good financing as if done by the individual on his own. This practice has been followed in the St. Catharines plant whenever possible; from 1905 to 1912 the savings having been sufficient to finance from time to time the construction of over twelve miles of distribution mains and some 2000 new services, the commission deeming it better financial policy not to reduce the rates because they had a surplus revenue for the time being, as our rates are low compared with other cities of our class, but rather to accumulate a reserve for any emergency or such extensions when required, all of such work being charged up to capital account, and increasing the assets on the balance sheet.

The principle is one, however, that has to be governed largely by local conditions of finance, rates, and laws governing the management of such utilities.

MR. A. A. REIMER: The paper presented by Mr. Reed impressed the speaker as being well worthy of study, and he was sorry it had not been presented in time to be printed in the March Proceedings, so that we could have studied it more; such a paper requires considerable thought. Our principal object in speaking at this time is to ask if we cannot have copies of that prepared and sent to those at least who have taken part in the discussion today, so that we can extend our discussions along other lines, if that is practicable.

MR. J. M. DIVEN: Under our present system of publication, the papers after being published are still subject to discussion, the discussion to be printed in a subsequent issue of the JOURNAL. That is one of the advantages of the present system as compared with the old.

MR. A. A. REIMER: The speaker will be glad to study the paper more carefully. The remarks made by Mr. Wills show that other places are using modifications of the general scheme after taking the money from the property owners temporarily. Now we had that plan to some extent, but never pushed it very much. We made a modification, however, that any person wishing an extension in a newly developed property, or a property that was on the map to be developed, would have to guarantee us a certain revenue. We were willing to pay the money for the work and capitalize it, of course, but we wanted to see a guarantee of a certain revenue that would meet a given percentage of the cost before we were willing to go ahead with the work. The result of that has been to prevent a great many wildcat schemes, and today an operator who wants to develop truck land counts his cost before he goes into it instead of having the city pay all the bills.

MR. WILLIAM LUSCOMBE: Will Mr. Reimer be more specific as to what that given percentage is?

MR. A. A. REIMER: In our case we call for 10 per cent of the guaranteed revenue. Then, if the promoter does not build a house along

that main and we get no water revenue, we are sure of at least 10 per cent on the cost. If he does not build any houses, he has to pay us 10 per cent anyhow.

MR. THEODORE A. LEISEN: The speaker has not anything special to say except that it might be interesting to state another instance of how such assessments are made. In Detroit for some years past the policy has been to make extensions wherever buildings are going up, on what is termed a "bonus" plan, the estimated cost of the pipe line being figured out, a bonus of 15 per cent per annum is charged, being supposed to be based on 5 per cent interest on the investment for three years, with the expectation that at the end of three years there will be enough built-up property to make it a paying proposition. The consumer is credited with whatever revenue may be derived from the water supply that is provided for the property at the time the main is laid, and the revenue so credited is deducted from the 15 per cent, the difference being the bonus which he has to pay.

PRESIDENT EARL: Your chairman was very much interested in this paper. Its statement indicating that the New Orleans water rates make no provision for vacant or unimproved property or other interests which are benefited by the water supply, but do not use water to participate in a fair proportion of payment for the benefits which they receive, is in error. The New Orleans rate, and the advocacy of the speaker's paper on water rates, tend very strongly toward a full participation by the taxpayer, as a taxpayer, for all of the benefits which he receives as a taxpayer. This is the very essence of a fair water rate for rate payers, because if any interest which is benefited escapes its fair share of payment, it is inevitable that some other interests or persons must pay an unfairly large proportion to cover the deficit.

There are so many conditions of law under which water works projects have to be financed, that it is a difficult problem to work out a fair distribution of costs and system of reimbursements to cover costs of extension, and also to arrive at a fair division of water rates, and still comply with existing legal restrictions.

Mr. Reed's paper advocates a plan for proportioning the cost of water works extensions, and arranging reimbursements, which appears to be equitable, under those conditions of law governing the financing of extensions which will permit of its adoption. This plan

relieves the water works from carrying unproductive property in extensions until they become reasonably productive, and places the burden of widely scattered extensions in sparsely built areas upon those who are benefited by them until the water consumption reaches a stage where the extension is fully warranted.

These are matters in which your chairman has taken a very deep interest, and which he believes are susceptible of formulation into a general system of financing, both for construction costs and costs of extensions and reimbursements therefor, and also of determining a division between the taxpayers' and the rate payers' fair share of the burden of maintenance and operation, including fixed charges, and finally of fixing the rate as between rate payers, so that all along the line these burdens will be equitably distributed, i.e., to say so that each taxpayer and each rate payer will bear his fair share of cost for each item of service which he receives, paying as a taxpayer for the benefits which accrue to all taxpayers, whether they are water consumers and rate payers or not, and as a rate payer for the benefits which accrue to water consumers only, and paying in proportion to his consumption for the items which vary in cost in proportion to consumption, and in proportion to the size of his service and meter for the items which vary in cost mainly in proportion to said size.

Several papers read before this Association within the last few years, including Mr. Reed's, just presented, contain matter of the greatest value, looking toward the formulation of such a scheme, and your chairman wishes a little later, as a member of the Association, to assist in presenting some further studies in these connections, with the hope that they may be of assistance in reaching something fairer and more uniform in the treatment of these questions than is shown in the widely varying general practice of today, and will be glad if the Association eventually can see its way to the endorsement of some general system of solution of these problems which would tend toward fairness and uniformity therein.

MR. FRANCIS C. HERSEY, JR.: There was a case in Wellesley this last year where a promoter laid out a remote section of the town principally in small bungalow lots for summer homes, etc. You know how these propositions as a rule pan out. For three or four years everything looks prosperous, then perhaps interest dies out and the whole thing goes to pieces. They wanted water and we esti-

mated it would cost us \$3000 to lay a 6-inch main into this property. We got the promoters to give us a surety company's bond for \$3000, guaranteeing that in case in any one of the five years the bond is to run the amount of water used (all metered) did not equal \$600, they would pay us the difference. If at the end of five years the development was a failure we would come out practically even on cost of extensions. If it was a success, we would be ahead.

MR. A. A. REIMER: The speaker takes somewhat the same attitude that the last speaker has expressed and in which others of the speakers seemed to concur, that the promoter has everything to win and nothing to lose. If they go into this game on their own basis we stand to lose, not to gain. Take the last case cited, having served water up to the limit of five years, how much was he in? We have to be very careful, if we adopt any of these plans, to see that we protect our city or our company, in case it is a private company, so that the time will not come when a heavy investment literally sinks into the ground and leaves a hole in our finances. Even if we get rentals for five years, we are out the water anyway.

MR. FRANK C. KIMBALL: It may be of some interest to state that, without laying down a formal rule to be applied in all cases, the Public Utility Commission of New Jersey have recommended in several instances that water and gas utilities make extensions of their piping systems for reasonable distances whenever the owner of the property to be benefited thereby will guarantee a return of 10 cents per foot per year upon all pipe so laid, for a term of five years.

MR. J. M. DIVEN: Most new land developments are more or less of a gamble and to leave the chance element all to the promoters the speaker has used the following method, considering that it is no part of the duty of a water department or company to go into gambling schemes; the promoters are required to pay all cost of pipe extensions into the property, including valves, fire hydrants, services, etc., with an agreement on the part of the department or company that it will refund the cost of the construction and take over the mains and appliances as soon as a certain number of houses have been erected, connected with the mains and commence paying a revenue, or when a certain specified income is received from the extension. Some portion of the capital furnished for the extension may be returned to

the promoters when a less number of houses than the full specified number are built and using water, or when a revenue somewhat less than a full paying one is received, but the contracts generally require the full number of water takers or amount of annual revenue before the mains are taken over and paid for. No interest on the cost is provided for in these contracts, the promoters standing that much as a part of their gamble.

By this method no money is advanced or invested by the water department or company until the development has proven a success and a paying investment for the water works.

MR. D. A. REED: Replying to some of the questions that have been asked; the paper refers more particularly to a municipal plant and still more particularly to the question of the establishing of equitable rates based upon actual cost, not only of the water supplied but the cost of extensions, it being the theory that the extensions should be assessable as nearly as practicable against the abutting property, and that the cost of operating should be borne by the customers using the water.

The question has often come up in our cities, how to make extensions in the streets where the people are not able to advance the money, as was stated by the first speaker. We often find that to be the case even under the present system. Our system embraces the idea that the utility itself should advance the money for extensions out of the depreciation, reserve and sinking funds or any other funds it may have available—temporarily. If money is used to make such extensions the property owners have the privilege of paying all that back into those funds at once if they wish; if not, 8 per cent is assessed yearly against abutting property, the idea being that the 8 per cent will eventually return all the money to those funds. It seems to the speaker unfair to make an extension under a straight guarantee system of either 8 or 10 or any other per cent. When extensions are first put in there are no customers. One extension made last year costing \$9000 had no consumers; there was not a house on the extension. As the consumption increases the total water rates will be deducted from that 8 per cent each year, so that at the time the total revenue exactly equals 8 per cent, the guarantee would be discontinued, and we would be getting only about half that amount because the other half of the 8 per cent would go to operating expense; in fact, in some portions of the system it would

cost much more than the total guarantee to operate, to say nothing of the fixed charges. For that reason this particular feature that the writer attempted to describe embraces the idea of crediting on the guarantee or assessment, by whichever name you call it, sometimes it is called a "guarantee" and it is sometimes called an "assessment," only that portion of the revenues which applies to capital investment. The balance of the water rates not credited to the frontage assessment goes to pay operating expenses as it should. If a man owns a 50-foot lot and his water rate is \$6 a year, one-half or \$3 is credited against the \$4 assessment that is placed against that property, leaving \$1 to be paid in cash. If he is using gas, one-third of his gas rate also is credited, the idea being that the half or one-third of the amount which he pays goes to pay the interest on capital investment of the entire plant. Generally a man's water and gas consumption wipes out his entire assessment. A vacant lot however continues to pay in cash the full assessment until enough consumers have been added to release the entire assessment. We have one section of the city that costs us over fifteen cents per one hundred cubic feet to furnish water. Under the old system of the straight 8 per cent guarantee the department or utility gets its money back when there is nobody using water. Up to the time, or nearly the time, when they were using enough water to retire the guarantee, we were losing money; and when the guarantee was discontinued, we were losing still more money for the reason that we had lost our 8 per cent returns on the investment and were furnishing water at about one-third its actual cost.

The speaker will be very glad indeed to have a full discussion of this subject. It is somewhat different from any system that has come to his notice but seems to have worked itself out automatically.

WATER FROM GRAVEL WELLS

C. W. WILES¹

The water supply of the Delaware Water Company, Delaware, Ohio, is obtained from rock and gravel wells, three miles north of the city, in a bend of the Olentangy River, covering an area of about 25 acres.

In 1909 an additional supply under the direction of H. F. Dunham, C.E., was obtained by running a suction line about 75 to 100 feet from the river, following its contour for a distance of about 1400 feet. On this line was constructed three deep rock wells, and thirteen gravel wells, the latter being 4-inch with 3 to 4-foot strainers, at an average depth of 28 feet.

During the dry summer of 1914 an additional supply was thought necessary and plans made for additional wells. A new suction line was laid at right angles to the old one, and connected to it with a 10-inch cast iron pipe, and 6 new wells were drilled in the open field some 400 feet from the old line of wells. In this location we found 2 or 3 feet of soil, 12 feet of sand, mixed with some gravel and small boulders, and 12 feet of coarse water bearing gravel. It was evident that at some time, this bend in the river had been its bed.)

With a well drilling outfit the new 6-inch galvanized casings were sunk to the rock at an average depth of 28 feet, then the casing withdrawn about 3 feet and a small charge of dynamite exploded at the bottom, after which the gravel was taken out and the casing carried down to rock again. A 6-foot strainer was placed inside the casing at the bottom, and held in place while the casing was withdrawn to near the top of the strainer, and a lead seal swedged to the top of the strainer. With a gasoline engine and small pump, the wells were pumped for 24 to 48 hours, until all sediment was taken out, and the water clear. These wells with the small pump showed a discharge of over 100,000 gallons each in 24 hours.)

In order to reach the same level as the original suction line, it was necessary to place the suction line for these wells 12 to 14

¹ Superintendent Water Works, Delaware, Ohio.

feet deep, this being just above the water line, at a time when the ground water was the lowest known in years. This gave promise of an abundant supply. These wells were then connected to the suction line, with a gate valve to each well to facilitate cleaning when necessary. During the low period of ground water we found that air was being taken into the suction, and some trouble was experienced with the pumps, and considerable inquiry by water consumers as to what we were putting in the water that made it look like milk.

A test of the main suction line was made by shutting off all wells, and an air pressure of 90 pounds placed on it, without any loss for several hours, showing that the air must come from some of the old wells put in in 1909. All these wells on being uncapped showed from 2 to 6 feet of water above the strainers. The only probable solution of the air trouble we could find was that when the wells were in use under suction the water level in the wells was drawn down below the top of the strainers at times, admitting air; and this must have been caused by the partial stoppage of the strainers, or a general low condition of water in the surrounding gravel. We found upon test that no air came from the new wells, the water level in these being 6 to 8 feet above the top of the strainers.

Some engineers having experience with this system of wells have suggested that our 4-inch wells are entirely too small, and that all such wells should be not less than 6 inches in diameter, but rather should have been 8 to 10 inches, with no strainers when in water bearing gravel, but should have perforations or holes in the bottom of the casing equal to one and one-half times the area of the pipe. Then instead of drawing the water from the body of the well, a smaller suction to be dropped inside the outer casing, well to the bottom, and connected to the suction. This would obviate the trouble of air finding its way through the top part of the strainer, and allow the well to operate until nearly exhausted.

This paper is presented for your consideration, with a view of bringing out suggestions of the best method of constructing wells in gravel.

DISCUSSION

MR. C. W. WILES: Mr. Chairman and Gentlemen, many of you do not rely on gravel for the water supply; but those who do know that it is a very important matter to know how to get water out of the gravel into the pump. The paper is simply a rehash of our sys-

tem of taking water from gravel, and it will interest possibly those who are similarly situated.

MR. W. J. HADDOW: The city of Brantford, a Canadian city, draws all of its water from gravel bar soil, using a different method altogether from that described by the writer of the paper. We have a long collecting gallery made of perforated tile pipe laid corresponding with the contour of the river, and the water flows down through it into a large concrete well. In case of low water we have an arrangement by which we can admit water from the river and cause it to flow to a central well from which it is distributed in various directions so that it will fall into this collecting gallery. By thus flooding the soil we obviate the low water difficulty.

MR. W. E. HASELTINE: We get our water from gravel. We have found in our case that we do not have to go more than 15 or 18 feet for it; it is comparatively near the surface. We have dug down to a depth of 15 to 18 feet and constructed a gallery similar to the gallery mentioned by the last speaker. The walls are laid with rock and reinforced with concrete cap. The water is carried from there into the well which is also located in the gravel, and the water is pumped from that. We, of course, have no trouble of the kind referred to by the gentleman who read the paper.

MR. JOHN W. MOORE: Throughout a large part of Indiana it is found desirable to tap the water bearing gravel stratum and also the underlying water bearing limestone stratum with the same well. One of the methods by which this combination well is successfully constructed is as follows: Assuming that the finished well shall be 10 inches in diameter, first a drive pipe 12 inches in diameter is sunk to rock, the depth and thickness of the water bearing gravel strata being carefully noted. A 10-inch diameter hole is then drilled to the desired depth into the water-bearing rock. A 10-inch diameter pipe is then lowered inside the 12-inch drive pipe and seated on the rock. One or more screens, 10 inches in diameter are made up and form a part of this 10-inch pipe, the screens being located so that they will come opposite the several water-bearing gravel strata. The 12-inch drive pipe is then pulled, which allows the water from the gravel to enter the well. In designing air lift pumping systems the writer has also used this method to secure the proper submergence.

MR. H. C. HODGKINS: There is a gentleman here who comes down from a district where they have the finest farms, and the population is largely German, even in larger percentage than here in Cincinnati. He is taking water from wells in a very unique way. The speaker would like to call on Mr. Hymmen, of Berlin, Ontario.

MR. H. HYMMEN: We have altogether about fifteen wells that we are using. Some of them are pumped by compressed air. We have started to use turbine pumps, direct connected, electric drive, which are giving us very good results. We had air on at first. When we first put in our air plant we pumped out sand and filled up our conduit. We then put on a small turbine pump, a 3-inch suction electric drive turbine pump, direct connected. We are getting 75,000 gallons in 24 hours. Some of these wells have 20 feet suction, and some 30 feet suction. They are down 32 feet in the well.

CITY FIRE LIMITS

BY ALBERT BLAUVELT

This is not a set talk, and if any one can enliven the occasion by any question or remarks the speaker will be glad to have him do so.

A water works is of course an essential of modern fire protection, yet it is but one of twelve general factors or departments which go to make up the fire protection of a large city as a whole. One also of the twelve parts or factors of modern city fire protection is the "fire limits" or central district in which frame buildings are prohibited. This evening's talk is to attempt to show that our cities in general are more in need of higher requirements as to the fire limits, than of high pressure systems or larger water works.

The public usually gets its idea of the presence of the water supply by seeing fire department hose streams. At time of disastrous fire the unfortunate practical fact is that such a fire is usually so large that it becomes a dry fire, one which does not receive any water at its heart, or core, and to that extent the water works is useless. Any one who is in the least accustomed to examining fire ruins can very readily tell whether water reached the heart or center of the fire, or whether the fire remained dry, and it is an unfortunate fact that the important fires are oftentimes dry at the center or precisely where water would do most good were it possible to apply it. Another still more unfortunate fact is that the bigger a fire, the more certain it is to be a fire which may be termed a dry fire. That is peculiarly a characteristic of all very heavy city fires after the hot blast has developed.

The conflagration of the city of Chicago in 1871 was such, and typical of the most destructive type of conflagration, and is especially interesting in connection with the particular viewpoint that we will come to later.

When Chicago had its great fire the city then had but about 350,000 inhabitants. While that fire originated at a point which is now inside the fire limits, yet the fire of 1871 was typical in its day as an outskirts fire and from that outlying place of origin burned into and through the city proper.

Another of the older of the modern city fires, that at Boston in 1872, was typical of another type of conflagration which begins in the heart of the city, and in the teeth of the fire department, then goes on and develops into the conflagration form.

Toronto has had several severe fires mostly starting in some cheap district where special fire protection would be a financial impossibility.

The Baltimore conflagration was carefully analyzed by men who had studied earlier conflagrations, and is more accurately mapped and platted than any other conflagration. It began in the face of the fire department, in the heart of the city, with no high wind, no severe weather, everything favorable for fire department operations, with lavish supply from the water department, and in broad early daylight. The wind during the whole period of that fire was very moderate as shown by the United States Weather Bureau, and yet, if that wind had not shifted toward the bay or harbor there would have been little left of Baltimore. These typical examples of very heavy and disastrous city fires, some of which started in town and some out of town, were dry fires each and all.

We are often indebted to our newspaper friends for some acute observations, for instance, the *Chicago Tribune*, with reference to the Baltimore fire, has this to say:

It was a great fire, and a peculiar one, in that it was a dry fire, that is to say, not a quart of water reached the central portion of the conflagration. The temperature of the fire that beat against and into the skyscrapers was probably 2000°. It was a terrible assault. The unprotected window openings afforded easy ingress to the fire, and plenty of woodwork was found on the inside for the flames to feed upon.

This *Tribune* report was absolutely accurate and we must also remember that the Baltimore fire was no more dry than preceding conflagrations all have been and to a certain extent must ever be.

Another thing that is misleading, although it is extremely natural, but it is unfortunate, is that we habitually speak of the burning of buildings. Now buildings do not comprise a city. A city is composed of contents, and the buildings are merely accessory to the contents. It is the contents that ignite, it is the contents that represent the bulk of values and fuel. We may say that the spectacle or phenomenon of a conflagration should be looked upon not as one building burning another, but as the contents of one building communicating the fire to contents of the next building. The contents

are the important things, both as to the hazard, the quantity or bulk of combustible material, and the value.

At Baltimore the steel frames that stood after the fire were simply rough shells of what were formerly buildings and their contents. Some people imagine that those frames represented a considerable salvage. Unfortunately they represented very little salvage as compared to original values plus tenants' property. The people who occupy office buildings have a great deal more property as tenants than they themselves know, anywhere from \$50,000 to \$150,000 per floor is not at all uncommon. The burning at Baltimore was not so much from building to building as from contents to contents; and the prime cause of the destruction of the so-called fireproof buildings was not the general fire but the contents of said buildings, however slight those contents might appear.

When you use steam boilers, you expect a pound of fuel to evaporate about ten pounds of water. When you burn a pound of fuel in a foundry cupola you expect it to reduce far more than its own weight of metal, and the same rule that applies to the ordinary furnace equally applies to the destructive or reducing power of fuel inside a building. The Continental Trust Company Building at Baltimore is a case in point. This was a bank underneath an exclusive office building. The contents were simply ordinary desks and furniture, trim, office files and so on, which one would hardly think of as sufficient fuel to reduce all to a gaunt skeleton, yet the destruction was brought about mainly from the mere contents.

It may seem unreasonable to state that a fire can be dry with the fire department at work, and considering that Baltimore had lavish water works. That is a perfectly pertinent question respecting all heavy city fires, with the fire department in operation, and the water works also in full operation, and, if so, why have either? The answer is that had it not been for the water works, and had it not been for the fire department, the fire at Baltimore would have reached enormously greater dimensions than it did. The fire departments were not able to do anything at all in the direct central path of the fire, but local and visiting firemen did an immense amount of good in hemming in the edges and so preventing the fire from cutting a much wider swath, and also did an immense service in checking fire from fire brands which were thrown far in advance of the main fire.

Why it is that these heavy fires get no water where most needed is something which many of you already appreciate yet it may not

be amiss to try an explanation of it. The principle is a simple one. Let anyone hold the hand over the flame of a candle. You will find that the heat is not bearable to the hand even at a considerable distance when held directly over the flame. It is also noticeable that there is a strong upward draft although the air in the room may be quiet. In any fire the expansion of gases due to the combustion speeds up the draft and we can calculate the velocity of the draught of a large fire from the manner in which it is able to throw firebrands. In a rough way it is a fair statement that the acceleration of draft local to, and immediately proceeding from, a fire is about four to one. That is to say, a 10-mile breeze fanning a fire is accelerated into about a 40-mile wind as it issues from that fire; and a 25-mile wind supplying oxygen to a great fire will accelerate up to approximately 100 miles an hour as it comes out of the fire. All this is consistent with the action of a large fire as to its throwing heavy firebrands to great heights and long distances. It does not take a very large fire to produce a dangerous hot blast and if the wind is sufficient to carry this hot blast over into a fairly horizontal position, the firemen are then held at a distance and cannot endure the hot blast and must retreat. The rear or trail of the fire necessarily is a bed or trail of burning embers. The fire department cannot work on the front or rear of a great fire simply because the hot blast occupies the front and an area of burning ruins occupies the rear.

Illustration No. 1 is intended to show the action of the hot blast as if it were visible. Any one who will take a slow speed fan and set a candle in front of it, will find it impossible to hold the hand close to that candle sidewise as is natural because the heat is then carried to the side. A house fire in a wind acts the same except, as is illustrated, it is on a larger scale. In small fires like a single house a hose stream is long enough to overreach the hot blast. But when the fire is a large one and fanned by a brisk wind, as shown in the main or lower figure of the illustration, it makes no difference how powerful the hose stream is, no hose stream can overreach the length nor the diagonal width of the hot blast and, therefore, the core or heart of the fire remains dry.

At Baltimore the wind did not at any time exceed twenty-five miles an hour; but there were times in certain streets when firemen could not stand within several hundred feet of the front of that fire. The hose streams were absolutely ridiculous and such is the situation in all large fires in a wind; the hot blast makes it impossible for

the firemen to hold a front stand to head off the fire. Such fires have never been controlled by any water works or any fire department, and from the nature of the case they burn a wide swath through a city unless the wind dies down. The Chicago fire simply burned on through into the lake. At Baltimore the fire burned out to the harbor. At Lynn, Massachusetts, it burned out to the Atlantic Ocean.

Coming to the question as to whether these hot blast fires can be prevented, or whether we must expect to have more cities wrecked, it seems certain that there is no complete remedy and yet there is at least a seven-eighths remedy. In the outskirts of cities no human ingenuity can suggest a remedy that is within financial bounds. A fire may come from this, that, or the other cause on the outskirts where cheap property cannot bear the cost of any effective anti-conflagration treatment. There is, however, a great deal of ground for believing that the very costly central districts of a city can be protected in spite of a conflagration that comes in from the outskirts, and that it is also possible to so protect the central or costly district that a conflagration cannot arise within said district. Experience has shown that a number of heavy city fires after having gone wholly out of control have later been gotten under control because of reaching a location presenting the resistance of shuttered alleys. A thoroughly shuttered alley exercises a great slowing-up effect. Any fire on reaching a full set of shutters or wired glass is checked considerably and is checked further in crossing the alley and checked again severely by the second set of shutters or wired glass. This is not to say any two sets of window stops will stop any such heavy fire as at Baltimore; but the point is that merely a plain alley thoroughly stopped on two sides has checked some fires which were wholly beyond fire department control and points to general use of protected windows. Many fire protection engineers believe that to protect the window openings of the central district of a city would alone be sufficient as an anti-conflagration treatment. The thing needful is to prevent fire inside a building from coming out of that building, and thus keep the fire from reaching the contents of the adjacent building. Fires are fed by the interior contents of buildings. If fire originates in a building or enters a building on the windward side the thing essential is to prevent the fire escaping and spreading from out the down wind or lee side. Obviously a street main, however large, is not able to help us in this particular, after a hot blast has developed and the firemen are unable to hold ground.

Now, there have been some very interesting experiences that prove that this fatal communication from contents to contents does not necessarily have to be guarded against by fire walls nor by shutters or wired glass. It has been found that spread of fire from contents to contents can be checked by a spray as from automatic sprinklers. In fact, a dense spray seems more effective than a fire wall provided the spray is deep, perhaps if need be, as deep as the building.

The city of Boston in 1893 had a fire which was absolutely beyond the control of the fire department until checked by a sprinklered building, known as the Brown-Durell Building, a very large brick building which stood directly in the path of the brunt of the hot blast. The heat opened a large number of sprinklers and the hot blast was sufficiently absorbed by the volume of spray and that hot blast did not emerge on the lee side of the building and the town was saved. Another sprinklered building, the Kilgour, is also credited by good judges as having been of similar service in Toronto in 1904. The spray must be deep, must be backed by a large water supply and must be inside, not on the outside, of the building, because outside spray blows out of place and away in a wind such as always exists at a time of conflagration.

As earlier stated, cheap property cannot stand the expense of preparation to positively stop the spread and run of fire, but it is commercial and also possible to prepare a costly congested district to do so and also to stand the brunt of any fire from a cheap district. This means the establishment of special fire limits inside of the ordinary fire limits, using waterless sprinklers and fire department engine water for some buildings, protected windows on other buildings, automatic water supply sprinklers in other buildings, etc., always keeping in mind the principle of intercepting the communication of fire from contents to contents. Such protective features because of cost would be mostly limited to a four-story or higher district or to city values aggregating not less than \$100,000,000 per square mile.

The fire that attacked the Brown-Durell Building was burning up values at the rate of \$800,000,000 per square mile, and in such a district an inner fire limits would be cheap in relation to the risk and the values at stake. A city carries about nine-tenths of its values upon about one-tenth of its area. Experience with those few very heavy city fires that have been checked has shown very conclusively that they cannot be stopped at any exact dead line but can be stopped within one or at the most two blocks as shown on the illustration.

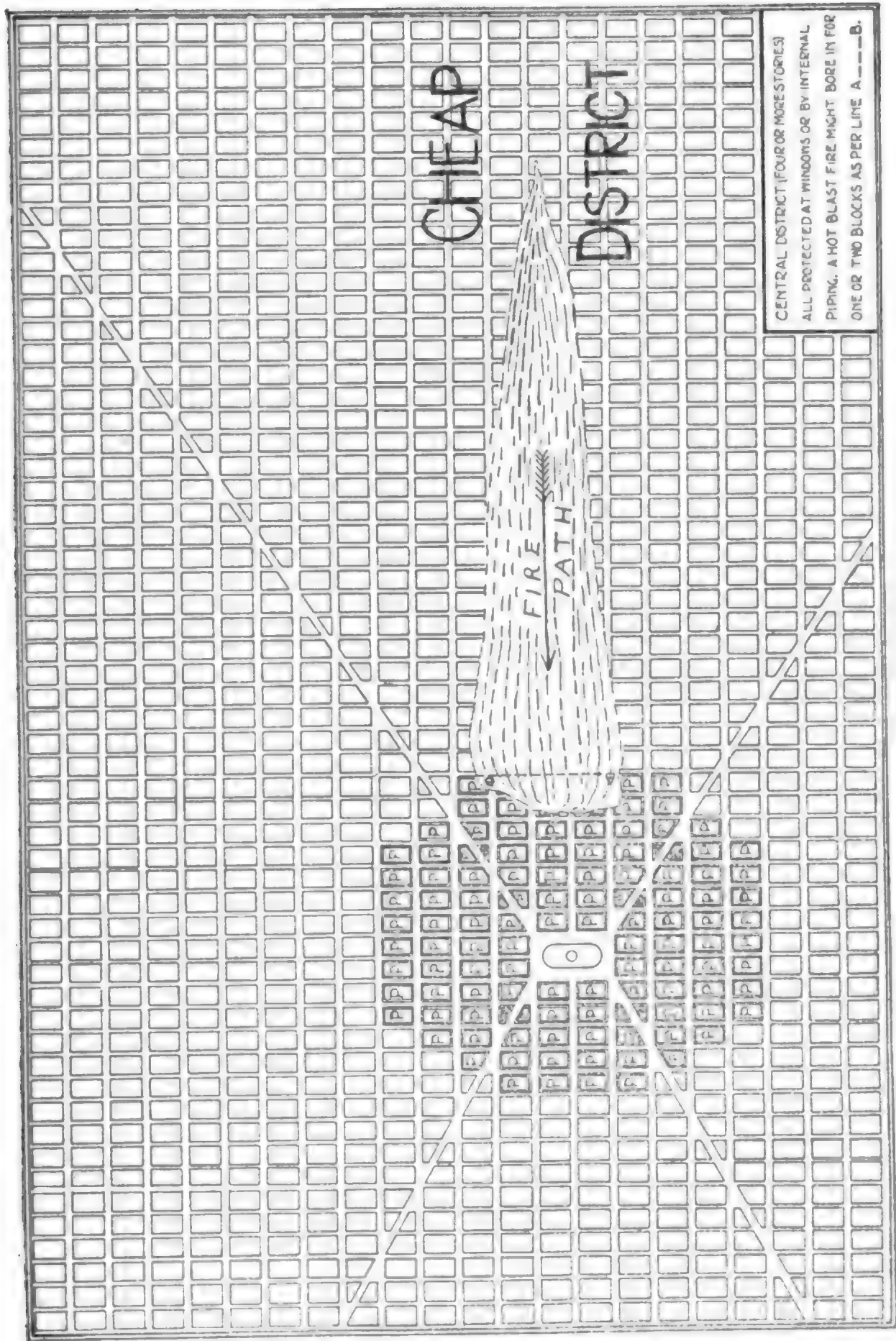
Because firemen cannot stand against a hot blast longer than the length of a hose stream, we cannot, therefore, through firemen or through water works expect to make safe our large city values. But we can establish an inner fire limit wherein the hot blast would either be deflected by successive barriers or be absorbed by spray, or partly deflected and partly absorbed, so that the fire shall subside sufficiently to permit the normal operation of the fire department and be within the capacity of the average water works.

The second illustration shows an inner fire limit (the group of blocks marked "P"), indicating a district in which every building is piped for sprinklers or, if not, has protected windows on all sides.

It seems to the speaker that our big cities can spend money to far better advantage to deflect or absorb hot blast fires from driving through their central districts than for heavier water mains or larger fire departments. It makes no difference what pressure may be used nor what water is provided as against the fact that no water works nor fire department can cope with a well developed hot blast. Better to agitate for checking the hot blast rather than expect the impossible from the fire department or the water works.

An inner fire limit as described is not likely to be put into practice at any very early date; the difficulty of apportioning the expense is very great. It involves the necessity for coercing the property owners as to their individual properties, and there are many such reasons which probably will for a very long time prevent our large cities from establishing inner fire limits to resist attack of a hot blast from a cheap district; and yet conviction seems unescapable that eventually something of that kind must be done. Our cities are growing and the values are piling up. We have never had any true hot blast checked by any fire department or water department, and we cannot have. We also have never had a really big fire yet as compared to the chances in our great cities. These conflagrations lie in wait for our big cities, and ordinary arithmetic indicates that some of these fine mornings we will wake up and find some city of a million inhabitants wiped out and with it a realization will come that a very small percentage of such an appalling loss if applied to central protection would have protected all of the larger cities and also paid its way on a yearly fire basis.

In this problem of city fire protection the real need is on the part of the citizens of the town and the individual building owners to rearrange the city plan proper.



CENTRAL DISTRICT (FOUR OR MORE STORIES)
ALL PROTECTED AT WINDOWS OR BY INTERNAL
PIPING. A HOT BLAST FIRE MIGHT BORE IN FOR
ONE OR TWO BLOCKS AS PER LINE A---B.

DISCUSSION

A MEMBER: How about water curtains; are they effectual in stopping fires?

MR. BLAUVELT: Water curtains are not of very much good except for a moderate fire. When there is a constant heavy fire blast bearing on a building a depth of spray about as deep as from here to the other side of the hall is needed and this can only be had in sprinklered buildings with heavy water supply.

A MEMBER: About the Salem fire; was that a fire which came in from the cheap district?

MR. BLAUVELT: Yes, sir; started out in the thinly settled district and burned down into the town. A city like Salem, however, could not be protected by any engineering short of reconstruction. What has been said must apply to fire limits inside of what is now recognized as modern fire limits. An inner fire limit as discussed is applicable only inside of what are now known as "fire limit districts" in which shingle roofs and frame buildings have been eliminated. Salem was a town of much frame and shingle roofs, and there are no engineering plans that might meet that situation.

ARTESIAN WELLS AND METHODS OF PUMPING THEM

BY JOHN D. KILPATRICK

NECESSITY FOR WATER SUPPLY FROM UNDERGROUND SOURCES

During the several years the speaker has been attending these conventions, he has observed that the papers and discussions on water supplies have been confined, in a great measure, to the treatment of water obtained from surface sources. These discussions have gone into considerable detail regarding the proper design and construction of filter plants, the design, construction and operation of filter beds, and a number of papers have been read on the proper method of still further destroying injurious bacteria which may have escaped elimination in the filter beds. But, there has not been much discussion on the subject of the design, construction and operation of water supplies obtained from underground sources, particularly those from driven wells.

In a great many localities the underlying formation is such that a water supply from a driven well system is impossible to obtain, but there are hundreds of municipalities where it is possible to obtain an artesian supply and consideration should be given to this source, even when a filtration plant is available.

A great point has been made in the discussions before this Association and also in reports of consulting engineers that artesian supplies are not permanent in character. The writer disputes this point, because his experience, extending over a great many years, has led him to believe that the fault is not with the underlying water bearing strata, but either with the construction of the wells themselves or to bad condition, due to neglect. It would be folly to generalize to the extent of saying that it is possible to draw an unlimited quantity of water from any given water bearing strata any more than the statement might be made that an unlimited quantity of water can be obtained from any surface stream, but there are many cases where the yield from the wells has steadily fallen off and where it was possible, by developing the wells and possibly changing the methods of pumping, to bring the wells back to their original and sometimes to

an even greater yield. For example, the wells of Montgomery, Alabama, which gave some years ago about 5,000,000 gallons of water per day had dropped off until it was possible to obtain only 4,000,000 gallons per day. By cleaning out the strainers and developing the wells, and by this latter term is meant cleaning out the fine sand which had collected in the region surrounding the strainers, and installing a more efficient type of air-lift, these wells were brought up to yield approximately 5,500,000 gallons per day. This was in a sand formation. A number of similar instances could be cited, but lack of time will not permit. The writer refers particularly to wells driven through sand or gravel formation where the use of a strainer is necessary. Of course, in the case of wells driven into the rock, it is only possible to obtain from any rock hole the amount of water contained or flowing through the crevices and fissures in the rock. With sand holes, however, the yield from any well is greatly affected by methods of construction and development of the well when drilled. The writer has drilled wells that yielded 15 gallons per minute which have been brought up to over 300 gallons per minute before being put into service.

In locations where there is a choice between artesian well water and a surface water supply that has to be filtered before it is possible for the water to be used, more consideration should be given to an artesian supply if the cost of the plant and the cost of water delivered to the pressure pumps is close enough to allow of debate. This opinion is based solely on the ground of the purity of the supply. After hearing the many interesting papers that have been read at these conventions on the subject of filtration for large municipal supplies, the writer realizes that there is a tremendous field for filtration and that it has solved the problem of water supply for a great many cities in this country and abroad; and further that for the larger cities in this country an artesian supply which has to be pumped to the surface of the ground is, in a great many cases, entirely out of the question.

The writer refers particularly to the purity of supplies from driven wells and admits at the same time that driven well water in almost every case is harder water than that obtained from surface streams. In very few cases, however, does driven well water have to be treated either to clarify or purify it. The installation of a filter plant for the clarification of a surface supply is not the end of that problem; ceaseless vigilance in the care of the filter is the only price of safety.

There are localities where it is debatable whether an artesian supply is better and more economical to operate than a supply taken from a surface stream that is to be filtered, and still other localities where there are no surface streams and the municipality is compelled to resort to artesian wells.

The problems involved in the laying out of an artesian well system may be grouped under three heads:

1. Location of the wells.
2. Methods of drilling and construction.
3. Methods of pumping.

No consideration will be given in this paper to the methods of pumping from the pump house up to the storage reservoir, nor to distribution systems. Only the delivery of the water to the suction basin in connection with the main pumps will be treated.

LOCATION OF THE WELLS

The location of the wells depends upon the extent and surface conditions of the land available for the well field. No rules can be set down for the proper location of wells until test wells have been drilled, unless the underlying conditions are known from wells in the vicinity. In laying out a pumping plant which will obtain the supply from wells, as a general rule, it is best to drill the wells and locate the pump on the lowest possible ground available. The obvious reason for this is that in drilling the wells we penetrate to the underground stream and the object is to have the pumped level of the water as close to the surface as possible, because as a general rule it is more expensive per foot of pump head to deliver the water to the surface of the ground than from the surface reservoir up to the storage tank. If the well field is to be in a well defined valley, it is preferable to drill the wells in a line across rather than parallel with the direction of the valley, because the underground stream of water may flow in the same general direction as the surface streams. This, however, is not always the case, and before locating definitely any number of wells, it is advisable to drill test wells at various points. There have been cases where city councils have taken the matter into their own hands and have drilled wells on the summit of the hill on which they have decided to place the storage reservoir under the specious reasoning that if they could get a flowing well in the valley, they should get on top of the hill a flowing well delivering its water freely into the storage reservoir, which would save the ex-

pense of pumping. Unfortunately, water will not rise above its source and the money spent on drilling these altitudinous wells has been thrown away. There are places where it is possible to obtain flowing wells on the summits of high hills, but they are the exceptions which merely prove the rule.

In regard to the location of underground water supplies by the use of forked sticks, magnetic balls, pendulums, indicators for radio activity and other devices, the belief in such occult means is only evidence of the survival of a superstition of the alchemist's age. The writer has known some of the most famous of these so-called "dousers," but has never yet been able to pin them down to statements which they were willing to back up by a bond.

This afternoon the speaker went out into the country and cut a couple of forked sticks; whether these forked sticks are from peach trees, witch-hazel bushes or not, is immaterial. Placing this glass of water on the floor you will note that when one branch of the fork is grasped with the right hand and the other with the left, in walking over the glass of water the stem of the fork dips. You note that the dip takes place. Now, walking down the aisle you note that the stick dips again, showing that the presence of water has nothing whatever to do with the curious action of the stem of the twig. The explanation of this phenomenon is that it is only possible to operate a forked stick when the hands are held palms up. This position brings the little fingers of each hand on the inside. You will note after holding your hands with palms up, your fists tight together and gripping hard, that within a few seconds you will feel a strain on the muscles of the forearm which can be instantly relieved by releasing the grip of the little finger a trifle and possibly the third finger also. If you are holding the forks of a twig in your hands the release of the grip by the little finger and the third finger, together with an almost imperceptible turning of the fist downwards and inwards, will cause the stem of the twig to dip. This, accompanied by a releasing of the tension on the pro nator muscle that extends from the thumb side of the wrist diagonally across the forearm to the inside of the elbow, when the hands are held palms up, is the explanation of the dip. The mysterious action of the twig, therefore, is not influenced in any way by the action of subterranean water, but is due either to unconscious reflex action on the part of the operator, or is caused by "malice aforethought" on the part of the same worthy when he thinks he is in the neighbor-

hood of a favorable spot for the location of a well. The reason for the continued vogue of the uncanny action of the divining rod in the hands of these self-styled "water-finders" is due to the fact that the average citizen has a sneaking fondness for the occult; and when a "water-finder" makes good on the location of a well, the fact is advertised far and wide, and when he falls down, his failure is expected as a matter of course and is soon forgotten.

There have been a number of other methods used by "water-finders" that have come under the speaker's observation in the last twenty years. One of them, a Russian, had a mysterious box from which was suspended a pendulum. He would start this pendulum oscillating east and west and walk over a tract of land; and he claimed such mysterious power for himself and the pendulum that when he was vertically over the underground stream, the pendulum would stop oscillating east and west and swing in a northerly and southerly direction. At that point he would drive a stake; then he would start at the edge of the property again, a few yards further off, and walk in a parallel direction to his first line until the same change in the pendulum took place and then he would drive another stake. In this way he would plot out the direction of an underground stream. The violence with which the change in the swing of the pendulum took place would give him an idea of the depth. This scheme was all right and the Russian made a great many thousands of dollars out of it. No one, however, ever saw the box or the pendulum, which he concealed under a long and wide coat which he always wore. His compensation was based upon his demanding a fee of \$100 for making what he called a "survey," and then getting a fee of \$500 if his predictions came true. The old man generally arranged to go to the neighborhood of the tract two or three days before his formal survey and gather all the information he could about wells in the vicinity, and by taking differences in the level of the ground, he sometimes made very close guesses, and, as remarked before, you only heard about his successful surveys and never about his failures.

Another famous "douser" in New York asserted that he could feel the underground water in the ends of his fingers if he walked over the suspected territory with his arms outstretched. There was another one who had a box containing mysterious electric indicators by which he registered the radio activity of the underground water. This radio activity of the underground water acted in an opposite direction to the force of gravity and passed through concrete cellars,

flooring, the roofing and all other materials, so that it was just as easy for him to discover underground water from the roof of a ten story building, as it would be in the cellar of the same building. This man "got away with it" for three or four years, because, as we all know, there is one gullible person born every minute.

The only scientific method of determining the location for a well is to obtain all the information possible about wells in the vicinity together with all possible data regarding the underlying geological formations. A combination of experience with the aforesaid data and information is of considerable value. In addition to this information, test wells should be drilled to the maximum depth considered necessary and should not be less than 6 inches in diameter so that a pump of reasonable size can be installed and some conclusion drawn from the yield of the "prospect well." After these "prospect wells," the number of which will depend upon the local conditions, have been drilled and tested, sufficient data is at hand upon which to estimate the total number of wells that will have to be drilled to give the required yield. Great care must be taken to obtain an accurate record of all the formations passed through and frequent tests must be made to determine the yield at different depths.

METHODS OF DRILLING AND CONSTRUCTION

Driven wells may be roughly divided into two classes: (1) those where the water supply is obtained from the rock, and (2) those where the water bearing strata lie above the rock. A third class might be added, a combination of these two.

1. Where the rock lies at a short distance below the surface of the ground and the quality of the water above the rock is unsatisfactory, the pipe should be driven so as to seat firmly into the rock, shutting off the surface water. The most satisfactory method of doing this work in the case of the 8-inch finished hole in the rock, is to drive a 10-inch pipe down to the rock and drill a 10-inch hole in the rock far enough to be surely into the solid rock and below the shattered and seamy top surface. An 8-inch pipe should then be lowered to seat into the bottom of the 10-inch hole in the rock and cement grout poured in sufficiently to fill up the annular space around the 8-inch pipe in the 10-inch hole in the rock. After this is set and the 8-inch hole drilled on in the rock, the 10-inch pipe may be withdrawn for use in another well.

During the drilling of the well, tests should be made by means of

sand bucket or working barrel to determine the yield at different depths. A good indication of passing through water bearing crevices is the rise or fall of the standing water in the well. If continued drilling shows the same character of rock and the standing water level remains the same, it is a good indication that there is no great change in the possible yield of the well. Another indication of very little water in a rock well is shown by a great rise in the water level in the well when the drilling tools are lowered. When the well has reached the required depth, a test should be made, either with the working barrel, or the air-lift. If there are a number of wells to be put in, and the air-lift system is to be adopted for the permanent pumping plant, and the test is made with a working barrel, it is advisable to place the working barrel at a point below the surface so as to leave sufficient depth for the submergence of the air-lift. For instance, if the wells are 200 feet in depth, the writer would not recommend that the working barrel be placed more than 100 feet below the surface of the ground and the yield determined at this point.

2. The construction of wells in sand or gravel. In driving wells through sand or gravel, it is essential that the drive pipe be of strictly wrought iron and equipped with patent recessed couplings, and care must be taken so that the ends of the pipe butt in the couplings and that the pipe be shod on the lower or cutting edge with a steel drive shoe. The reason for the pipe butting in the couplings is to carry the effect of the blow of the tools directly through the pipe to the drive shoe instead of having the impact come upon the threads in the couplings.

The proper strainer and the placing of it is the next point to be considered. If the strainer is to be placed at the bottom of the well, this may be done either by driving the pipe through the water bearing strata, introducing the strainer, and jacking back the drive pipe so as to uncover it; or the drive pipe may only go to the top of the water bearing sand and the strainer pumped or driven into proper position. In the first case the strainer may be plugged before being lowered, but chances would be taken in the ability of the well driller to jack back the drive pipe. In the latter case, difficulty is sometimes found in placing the plug securely. In either method of construction, it is essential that means be taken to prevent sand from running up alongside the strainer between the top of the strainer and the well casing. This sand is kept out either by putting in a

lead packer or by continuing an extra line of pipe from the strainer up to the surface of the ground. Where the lead packer is used, the strainer is lowered into the hole, and in order to withdraw it any time, considerable difficulty is usually found in getting hold of it and getting it out of the well without destroying the strainer. As a general rule, it is better to lower the strainer into place by means of piping extending all the way to the surface of the ground and then, if it is necessary at any future time to withdraw the strainer, it is a comparatively simple matter to do so. In case the water is found in three or four strata with some distance between them, it is necessary to drive the pipe to the extreme depth and then lower the strainers into place with the proper connecting pipes between them, and then jack out the well casing at least as far as the top of the uppermost strainer.

The operation of jacking back pipe is one involving risk on account of the pipe parting under the strain. The only precautions that can be taken are to sand pump freely and frequently when the pipe is being driven, have the strainers on the ground and lose no time in placing the strainers before jacking back the pipe, so that the sand and gravel will have as little time as possible to pack around the drive pipe couplings. Cutting the drive pipe may be resorted to in case it is unnecessary to withdraw the lower part of the drive pipe, which may have been driven to give the necessary amount of submergence in the case of an air-lift well. The necessity of insisting upon the pipe being butted in the coupling is observed more particularly when jacking operations are required, because if the pipe is not butted there is even greater danger of stripping the threads. In case a pipe parts when being jacked back, it may result in a lost well.

3. Under the third heading, where water may be obtained from the formations above the rock and from crevices in the rock, the construction of the well differs in no way from those referred to in the first two actions.

METHODS OF PUMPING

The pumping of driven wells may be done either by suction, deep well pumps, rotary or screw pumps, or the air-lift. In case the water rises high enough in the wells to be pumped by suction, it is unnecessary to speak of this other than to say that method of pumping is familiar to anyone who has ever done any hydraulic work. The only

prime necessity for a successful suction plant is tight suction lines, and good foot valves.

In regard to deep well pumps, these may be used when only limited supplies are required and where the water does not rise in the well high enough to make an air-lift economical. The question of whether to use single acting well heads with single acting barrel, or single rods with double acting barrel or double rod heads with double plungers depends entirely upon conditions. Except under extreme conditions, the speaker does not believe it advisable to use deep well pumps where there are more than two wells on account of the spacing between the wells and the necessity of building separate pump houses over each well and for other obvious reasons of economical pumping.

For any number of wells scattered as they usually must be over quite an area, the air-lift system has proven itself to be the most available method for delivering a large supply of water on the surface of the ground. It is not advisable, however, to use the air-lift except under extraordinary conditions for delivering the water higher than to the level of the ground. At best the air-lift is an expensive way of pumping, but where the water is obtained in large volume below suction limits, it would seem to be the only possible method. The air-lift system has the great advantage of not having any moving parts in the well, and there is absolutely nothing to get out of order in the air-lift itself. The moving parts of the system are all in the air compressor in the engine room, under the eye of the engineer. The engine room may be located at the most convenient point, taking into consideration the supply of fuel, and the furthest well may be a mile or more away from the air compressor. If the air lines are correctly designed and properly buried, there need be but little loss of pressure. The main fault that the speaker has found with a great many air-lifts throughout the country has been in the air-lift piping in the wells. It is a familiar fact that a prime consideration for an economical air-lift is that there should be 60 per cent submergence. For instance, in a 100-foot well, there should be at least 60 feet of water when the well is delivering its yield; but the principal trouble is found in the design of the air and water piping, so that the compressed air is delivered at the bottom of the uptake water pipe with as little loss by friction as possible, and that the uptake water pipe is designed so as to deliver the water, without being so large as to have an extreme amount of slip or so small as to

develop excessive friction. Evidence of faulty design is shown by the discharge being in alternate pistons of water and air. In a properly designed air-lift system, the water should be discharged in a practically uniform stream, with very little surging. A great many foot-pieces have been designed which have for their object the spraying of the air at the bottom of the uptake water pipe so as to introduce the air into the water in streams of very fine bubbles. It was discovered early in the development of the air-lift that the finer the spray could be made, other things being equal, the more efficient the air-lift became; but no foot-piece that was ever designed can work efficiently if the air pipe leading down to it and the uptake water pipe from it are not of such sizes as are suitable for the particular problem involved in that well. The great object to be accomplished by any foot-piece is to offer as free and clear a water passage as is possible so that there will be no eddies formed in the water column which cut down the velocity and impair the efficiency. Above the foot-piece the mixture of air and water should have a pipe with as smooth surfaces as it is possible to obtain.

The three methods of piping wells may be termed: (1) the outside air pipe; (2) the inside air pipe; (3) the annular system. In the first case the air passes down outside the water pipe and into some type of foot-piece or openings at the bottom with the water passing up through the inside of the water pipe. In the interior pipe system the air passes down the inside air pipe to a foot-piece or nozzle, and the mixture of air and water is blown upward between the outside of the air pipe and the inside of the water pipe. In the annular pipe system, one pipe is within the other, the space between the two pipes being the downtake air column, and the interior of the inside pipe being the uptake water discharge pipe. It is impossible, without an exact knowledge of the conditions, to determine which of these three systems it is best to use, assuming that the proper areas are available in each case for the amount of air necessary and the amount of water required to be lifted. There are cases where the diameter of the well is so small and the amount of water to be delivered so large that there would not be room in the well for the outside air pipe, in addition to the uptake water pipe. In this case, it might be better to use the well casing as the downtake air pipe and only provide an uptake water pipe. This arrangement, however, is sometimes impossible on account of air leakage through the joints of the well casing, which were opened up when the well pipe

was driven. It is very hard to generalize and lay down rules for piping up wells on account of the different yields, depths and submergence of wells, and this is sometimes still further complicated by the number of wells that have to be pumped. With a great number of wells to be pumped from the same air compressor, very delicate adjustments are required so that all the wells may be started at the same time. The speaker believes that it is preferable to use a single air line, with outlets to each of the wells, rather than separate air lines from the pump house to each of the wells, both as a matter of economy of installation and economy in the use of air. The plea sometimes made that independent air lines to each well allow of adjustment within the engine room is valid because the place to adjust the well is at the well itself, and if the plant is properly designed originally, it should not be necessary to adjust the wells except at considerable intervals of time, and then only because of the increased requirements made on the plant, or fluctuations in the wells themselves.

Another rule, the observance of which should be insisted upon, is that the air-lift should only be used to deliver the water high enough above the ground to allow of a flow to a surface suction basin close by the force pumps.

The writer has not referred to air pressure machinery, but considerable economies can be made in this part of an air-lift system by installing compound and condensing machines and by 2-stage air ends. The great loss of economy in the ordinary air-lift system, however, is not in the engine room but in the air-lift pump in the wells. Insufficient submergence, caused by pumping too great a quantity from a well, and thereby lowering the head to a point where the increase in the amount of air necessary is out of all proportion to the quantity of water obtained, or by the use of piping either too large or too small. No foot-piece ever designed will do the impossible, but a properly designed foot-piece in connection with correctly designed air and water pipes will make the air-lift an important factor in the pumping of deep wells, and a properly designed air-lift system in connection with wells that have a good flow of water will result in pumping costs which will compare favorably with the cost of some surface water supplies that have to be filtered.

DISCUSSION

MR. CHESTER R. MCFARLAND: What do you find to be the most efficient velocity of the water rising in the pipes?

MR. J. D. KILPATRICK: The most efficient velocity depends upon the air pressure, the size of the pipe and the depth of submergence. The velocity should be so low that the friction in the uptake pipe is negligible.

A MEMBER: What is the highest efficient velocity which you can get?

MR. J. D. KILPATRICK: As stated before, this depends upon the pressure. The speaker has never made any experiments to determine the velocity in feet per second of the discharge of the air-lift well, but in accordance with common practice, has made calculations in gallons of water discharged per square inch to the area of the uptake water pipe. In a deep well with high air pressure the speaker has discharged as high as 29.5 gallons per square inch, and recently, in New Jersey, was able to obtain a discharge of 31 gallons per square inch. With shallow wells, and consequently lower air pressure, the usual discharge is from 12 to 15 gallons per square inch.

MR. CHESTER R. MCFARLAND: The water had to travel the whole length of the pipe or you would not have had a discharge.

MR. J. D. KILPATRICK: That is true. The velocity is a question of simply dividing the area of the pipe by the amount of water discharged per minute to get the velocity.

MR. CHESTER R. MCFARLAND: In an experience extending over a period of about twenty years, the speaker has been led to believe that each individual case must be treated according to the conditions as they are found, and that a deep well with a very great submergence and high lift will require a greater velocity than the one of much less depth, to secure the highest efficiency of the work done by the compressor. This being the case, for the same quantity of water delivered from a deep well the area of the water pipe should be much less than that in a shallow well.

MR. J. D. KILPATRICK: The government specifications issued by the quartermaster's department of the United States Army seem to be based upon the wrong conception of the operation of the air-lift. These specifications call for double, extra heavy pipe on the top, extra heavy pipe for the middle lengths, and standard pipe for the lowest lengths. Piping the well up in this manner means that the area is smaller at the top than it is at the bottom. The arrangement of the pipe should be reversed, that is, the smallest diameter should be at the bottom, and the largest diameter at the top. The reason for this is that the compressed air which is jetted into the water at the bottom is at its maximum pressure, and the bubbles are consequently smallest. As they travel upwards in the discharge pipe, they expand, and the pressure becomes less, with the result that more area is necessary at the top of the water discharge pipe than at the bottom, on account of the greater space occupied by the expanding bubbles of air, the quantity of water being the same at the bottom as at the top.

A MEMBER: What do you do when you have a rock only about 150 feet down?

MR. J. D. KILPATRICK: Let us suppose that we drive a 10-inch pipe above the rock, and desire an 8-inch hole in the rock. The operation would consist in driving a 10-inch pipe down to the rock, and the well driller will then continue with his 10-inch bit and make a 10-inch hole in the rock far enough to pass through the seamy top surface of the rock. An 8-inch pipe, with ordinary couplings and full lengths, is lowered with a coupling on the bottom of the lowest piece. This 8-inch pipe is lowered into the 10-inch hole, and the coupling on the bottom firmly set on the bottom of the 10-inch hole in the rock. The space between the outside of the 8-inch pipe and the inside of the 10-inch hole in the rock is filled with liquid cement grout up to the top of the rock. The well driller then proceeds to drill the 8-inch hole in the rock as far as necessary, and at some convenient time pulls out the 10-inch pipe which was driven from the surface of the ground down to the rock; the reason for withdrawing the 10-inch pipe is that there is no necessity for it, and it is available for use in another hole.

Several members have asked regarding the advantages of blasting or shooting a rock well. The answer would be that shooting a well

is resorted to in the oil regions to break up the oil-bearing sand, when this has been encountered. In shooting a well for water supply, a greater flow can sometimes be obtained if you are absolutely sure where the water bearing fissure in the rock has been encountered. The trouble with most well builders is that they cannot determine this exact point, and it may be that the shot is set at the wrong place, and may result in the closing up of the water bearing fissure instead of enlarging it. As a general rule the speaker does not believe that blasting a well is a sure way of increasing the water supply from that well, but at the same time there are a number of cases in which it has proven very successful.

MR. JOHN W. MOORE (by letter): The writer has had a wide experience in designing and remodeling air-lift pumping systems and the question the gentleman has raised as to the proper speed of the air and water in the eduction pipe is of very great importance. When this most advantageous speed has been determined for all conditions the writer suggests that with the information now at hand the average consulting engineer will be able to design successful air-lift pumping systems of the highest efficiency.

It is apparent that a constant velocity is neither desirable nor possible; therefore it would follow that the best that could be done would be to ascertain the maximum and minimum permissible velocity at both the lower and upper end of the eduction pipe, the velocity at the intermediate points to be governed by the diameter of pipe available and possible to install in the well.

The writer after running tests on many air-lift pumping plants of his own and other designs has decided on what he believes to be the most advantageous velocity of the air and water in the eduction pipe for lifts of from 30 feet to 175 feet.

If observations of plants the writer now has under construction should verify the information secured during the last four years, the writer will be pleased to lay such information before those of this Association who may be interested.

MR. M. N. BAKER: The speaker well remembers the water-finders, Hartdegen and Schnee. He had come to New York a few years before, and it was his duty to accompany those gentleman on several expeditions. On one of these we had some large hose with water running through it stretched around on the floor of a large vacant building. We took Messrs. Hartdegen and Schnee up on the floor

above and had them chalk out their indication of the stream of water. It is hardly necessary to say that they did not come anywhere near it. Of the many who witnessed their demonstration one man was a member of the American Society of Civil Engineers and another has since been a prominent official of the American Institute of Mining Engineers.

A few years ago the government auditor of municipal accounts refused to audit a bill that a British town council had incurred for water finding, and the members of the town council had to meet the bill out of their own pockets.

Hartdegen and Schnee shrouded their water-finder in mystery. Waterfinders of a later and the present day claim to use "electrical" instruments and put forth clever but blind explanations as to how they operate.

In 1910 some enterprising water-finder succeeded in interesting the Agricultural Department of India to make an investigation of his device. The department published an interesting little pamphlet purporting to show that the water-finder investigated was a good thing. That pamphlet has recently been circulated in this country by some one giving his address as Providence or Pawtucket, Rhode Island.

MR. WIRT J. WILLS: The speaker simply wants to rise to thank Mr. Kilpatrick for having introduced a subject that is very near and dear to him. The speaker has been a member of the American Water Works Association for ten years, and with the exception of one engineer making a feeble attempt to say something about ground waters, this is about the first time that anything has been mentioned in regard to pumping from deep wells, or at least anything in an exhaustive way. Representing presumably the largest artesian water plant in the world, all that the author of the paper said was very interesting to the speaker, who does not desire to make a talk on this subject, except to say that we have three systems in Memphis, all very successful. One invented by the speaker, the name of which he will not mention because it is not on the market, consists of fifteen one million gallon pumps, stretching over a distance of ten miles. During the drought, last summer, the longest dry season ever known in that country, our mayor published a card in the paper advising everybody to use all the water they wanted, but we kept up with the demand right along.

With thanks to Mr. Kilpatrick for introducing this subject, the speaker hopes in future meetings we will have more discussion on this topic.

MR. OSCAR BULKELEY: The speaker would like to ask Mr. Kilpatrick if he has found a good method of drilling a well so as to be sure of securing a straight bore. Of course it makes no difference if one intends to pump with air, but it makes a very vital difference if any other type of pumping equipment should be used. Perhaps the rotary method of drilling is the most successful, but the speaker wonders if Mr. Kilpatrick can furnish any information on this subject.

MR. J. D. KILPATRICK: In driving a pipe it must be remembered that the direction of the hole is entirely dependent upon the threading of the casing. The well driller sets his first length of pipe as near vertical as he can, drives this to its depth, screws on another length, drills that, and sand pumps and drives till he is ready for the other length, etc. The straightness of the hole depends upon the care with which the pipe company has threaded the pipe. The reason that so many well drillers get a crooked hole in the rock is that they drill with a slack cable. The well driller will usually get a straight hole if he drills on the spring of the cable, that is, with the tools hanging free in the hole, the distance off the bottom depending entirely upon the length of drill cable. In drilling with a taut cable the tools hit with a sharp blow, which is caused by the fact that the up stroke of the walking beam corresponds with the stretch of the cable. In drilling with a slack cable the tools do not hang free and clear in the hole, and the length of the stroke is cut down considerably. It is a very difficult job to drill a straight hole even with the best of care, if the rock is in layers of very hard and very soft material lying almost vertically. In this case the tools will be sure to work over into the soft material and make a crooked hole, in spite of all precautions. Sometimes a guide can be put on the stem, but in an experience once in Mexico every method known at that time failed, and we were forced to drill with a rotary drill.

MR. A. A. REIMER: The method outlined by Mr. Kilpatrick for obtaining a pipe joint in passing from soil to rock is of course a perfectly sure method; but oftentimes in fairly soft rock you can save

that expense if you have a good iron shoe. A well dressed shoe, you can drive into rock with a little care in keeping the tools going pretty close to the shoe all the time. The edge of the tool will cut say three-quarters of an inch of rock under the drive of the machine, so that you can actually drive your pipe right into the rock, perhaps 3, 4 or 5 feet. In some cases that is all that you need for cutting—a good drive. That is all you need in that character of rock; but in hard rock the other method, of course, is necessary.

MR. J. P. BERRY: We have four deep wells in our city, each being approximately 1378 feet deep, and we have had no trouble in drilling them straight. Three of the wells are 15 inches down to a depth of 100 feet and from there to the bottom they are 8 inches in diameter. One well is 20 inches to a depth of 200 feet and from there to the bottom 12 inches. These wells are pumped with centrifugal pumps. An agreement with the contractor was, that he must put down a dummy pump, the size of the pump to be used in the wells, to a depth of 200 feet and this dummy pump must pass in and out freely before any payments were made. This was to show that the hole was perfectly straight and that the pump could be inserted and taken out when needed.

These wells are pumped at the rate of 1,000,000 gallons per day. Two of these pumps are electrically driven with direct connected motors. One pump is electrically driven with a belt drive and one pump is operated by steam. These pumps have worked very satisfactorily with us. Electricity is purchased from a private company at a cost of 0.02 per kw. It costs about 0.01½ per 1000 gallons to put the water in the reservoir.

MR. OSCAR BULKELEY: The question of straightness is something that is of great importance; more than many realize. The speaker believes that there are a great many well men who have heard about straight holes, but have not got them. If we were to make a test of them we would find that they are crooked. There is a great deal of misrepresentation in regard to drilling a well straight. Contractors will say that they will drill a straight well, but they do not always do it.

MR. EDWARD S. COLE: Will Mr. Berry kindly tell us how his vertical shaft and pump are lubricated.

MR. J. P. BERRY: The shaft goes down inside of a 3-inch casing, and the lubrication goes down inside of that. There is no water around the shaft. The shaft goes from the motor connection straight through. One pump ran 18 months without missing a day. Some Sundays it was shut down for an hour or two, but it ran the whole 18 months practically night and day, delivering 700 gallons a minute. Then it was taken out. It has been very economical.

MR. WIRT J. WILLS: To find out whether a well is straight, if you have a contractor who cannot tell you, make him take a looking-glass and by looking down with that you can tell if it is not overflowing.

MR. FRANCIS D. WEST: This has been an important and interesting subject and the speaker is glad to see that the fact has been emphasized that the air-lift is a very good means of pumping deep wells.

IMPOUNDED WATERS OF ALABAMA IN RELATION TO PUBLIC HEALTH

BY EDGAR B. KAY

The streams of Alabama for nearly a century have been utilized for navigation, public water supply and as sources of power in the operation of cotton mills, saw mills, grist mills, gins, and other manufacturing plants. In these operations numerous dams have been constructed, the flow of the streams for a time impounded, partially controlled and regulated for the manufacturers and users.

Within the last few years the plan of canalizing the larger streams in order to give the inland cities, iron and coal interests as well as the diversified agricultural and manufacturing industries, the advantages of water transportation, has resulted in the construction of many large dams and impounding basins extending for hundreds of miles along the Alabama water courses.

The development of long distance electrical transmission of power has made available the hitherto inaccessible and remote potentiality of streams, which are being harnessed for the service of man and use in the upbuilding of the Commonwealth. The impounded waters resulting from the construction of dams and structures employed in the operation of these hydroelectric plants are important links in the canalization projects of the government to aid navigation. In addition these dams serve the important work of flood prevention by assisting in the regulation of the discharge of streams.

Out of the recent improvement and utilization projects in Alabama, there has developed a great deal of litigation. This litigation has been inspired, almost entirely, by unscrupulous lawyers and land sharks, who have systematically canvassed the territory contiguous to these hydraulic works and have made the credulous country people believe that they could secure large sums from the corporations developing these hydroelectric plants. Many of these people who are the perennial victims of chronic malaria and hook-worm anemia, have been led to believe that their latest troubles are entirely due to the formation of a large body of slowly moving

water in the vicinity, which body of water is nothing other than an enlarged section of the original river due to decreased velocity.

The largest power company in the state is at present defendant in some 700 suits, aggregating approximately \$3,000,000 damages claimed, these suits being filed in the four counties through which the lake extends, caused by the dam at Lock No. 12 on the Coosa River.

It is the purpose of this paper to briefly outline the character of the impounded waters in Alabama, in their relation to public health and to call attention to the necessity of having carefully made preliminary topographic, geologic and sanitary surveys in connection with similar future projects.

DRAINAGE BASINS

The five principal drainage basins of the state are:

First, The Apalachicola Basin, draining to the Chattahoochee and Apalachicola Rivers, and entering the gulf at Apalachicola, Florida.

Second, The Choctawhatchee Basin, draining to the gulf through Choctawhatchee Bay.

Third, The Pensacola Basin, draining to Pensacola Bay and Perdido Bay, near Pensacola, Florida.

Fourth, The Mobile Basin, including the waters of Tallapoosa, Coosa, Cahaba, Alabama, Warrior and Tombigbee Rivers and draining into the gulf at Mobile, Alabama.

Fifth, The Tennessee Basin, draining into the Tennessee River and thence through the Mississippi to the gulf at New Orleans.

The water powers of the state are mainly in the Mobile and Tennessee basins, which practically cover the entire state, except a small area in the southeast corner.

From Westpoint, Georgia, southwards, the state line of Alabama is on the west bank of the Chattahoochee River where ordinary vegetation ceases to grow. This leaves all of the water power of the main stream on Georgia territory.

The Alabama Geological Survey, in coöperation with the United States Geological Survey, has for a number of years been engaged in a systematic investigation of the water resources of the state.

The annual average precipitation in the northern district of the state is 51.23 inches, and in the southern district 51.47 inches. There have been wide variations from the annual average precipi-

tation. In 1900 the average for the year was 66.73 inches and in 1904, the year of minimum rainfall and run-off, 39.58 inches.

While the proportion of the rainfall which appears in the run-off of the streams varies between very wide limits, depending upon the geological formations, the locality, etc., in Alabama, on an average, about 50 per cent of the rainfall is lost through evaporation, and the remainder forms the run-off of the streams; and curiously enough, only a small percentage of this run-off is supplied by the surface water alone, for most of it reaches the water courses by underground seepage.

In the course of this underground circulation the water reaches the surface from springs, many of which are very large, such as those at Tuscumbia, Huntsville, and Jacksonville, which are the sources of the municipal water supply, from ordinary shallow and deep wells, and from artesian wells.

The main channels in this run-off system are navigable all the year for boats of light draft, except the Tallapoosa and Coosa Rivers, and the canalization of the Tombigbee and Warrior Rivers, by the construction of seventeen dams and locks, has established water transportation from the Birmingham district to the gulf. A fleet of self-propelled barges of 1000 tons capacity each is now making regular trips between Tuscaloosa, Alabama, and New Orleans. Iron is also moving from Holt, north of Tuscaloosa, to the gulf by the water route.

It may be said in a general way that the streams have their greatest fall in passing from an older to a younger geological formation. Tallassee Falls, on the Tallapoosa, and Wetumpka Falls, on the Coosa, are made in passing from the Crystalline to the Cretaceous. Those on Talladega Creek and other small streams in entering the Coosa Valley from the southeast in Talladega, Calhoun, and Chelburne Counties, are from the Crystalline to the Paleozoic. The shoals above Centerville, on the Cahaba, above Tuscaloosa, on the Black Warrior, and near Tuscumbia, on the Tennessee River, are made in passing from the Paleozoic to the Cretaceous. As the Coosa River runs off of the Paleozoic onto the Crystalline near Talladega Springs, the shoals above this point reverse the general order by being made in passing from a younger to an older formation.

The Crystalline area in Alabama is a plateau ranging from 500 to 2000 feet above sea level, of triangular shape on the east side of the state. The rivers flow over bed-rock in a succession of shoals and

eddies between high hills, and present conditions most favorable to the development of water powers with high head. On the Tallapoosa River at Tallassee Falls, a head of 64 feet has been partially utilized for a number of years in the operation of cotton mills, and also a 40-foot dam about three miles above Tallassee is utilized for the generation of electric current which is transmitted to Montgomery. At Cherokee Bluffs, about 15 miles above Tallassee, a dam 125 feet to 150 feet in height is contemplated by the Alabama Power Company.

The falls on Coosa River, from Marble Valley to Wetumpka, are 235 feet in 45 miles. During the past year a dam 60 feet in height has been completed at Lock 12 on this river, the hydroelectric power developed at this site being transmitted to the Birmingham district.

The Paleozoic area includes the greater portion of northern Alabama, being bounded on the southeast by the Crystalline area, and on the southwest by the Cretaceous and later formations of the Coastal Plain. The Paleozoic area is somewhat higher than the Coastal Plain, and slightly lower than the Crystalline area. Its rivers have considerable fall. There are many important creeks and many large limestone springs in this region. The area is rich in coal and iron, the most productive mines being in the drainage basins of the Cahaba and Black Warrior Rivers, the Cahaba River has a fall of 121 feet in 21 miles. The Black Warrior River above Tuscaloosa has a fall of 100 feet in 30 miles. The Tennessee River above Waterloo has a fall of 155 feet in 41 miles, 85 feet of which is in a distance of only 14 miles.

The Coastal Plain is a large area in southern and western Alabama, covering about two-thirds of the state, and is underlain by Cretaceous and younger formations. In the upper portion of this area the streams are not sluggish. There are many streams that have a constant water supply and sufficient fall for the development of good water powers. One of these is the Pea River, the main tributary of the Choctawhatchee River, on which a dam giving an effective head of 31.4 feet has been constructed and the power developed is being transmitted electrically to Troy, Alabama, 32 miles distant.

Birmingham's principal source of water supply is derived from the Cahaba River, on a branch of which—the Little Cahaba—a large impounding reservoir has been built.

The dams on the Warrior are utilized at present only for naviga-

tion, although efforts are being made to utilize the power at Lock 17 in connection with large impounding reservoirs to be built on the Mulberry Fork of that river.

Only a beginning has been made in the development of the great water power resources of the Alabama rivers. The largest available powers remain undeveloped. Of the nine plants now in commission, the Dadeville, Sylacauga, and Goodwater plants are municipally owned; the other hydroelectric plants are the state convict department's plant at Speigner, the Etowah Light and Power Company, near Gadsden; the plant at Lock No. 12 on the Coosa River owned by the Alabama Power Company; the Montgomery Light and Power Company, above Tallassee Falls; the Pea River Power Company, at Elba; and the Centerville Light Company, near Centerville.

While only a beginning has been made in the development of hydroelectric powers in this state, numerous power sites have been utilized ever since the state was settled, for manufacturing purposes, such as the operation of cotton mills, cotton gins, grist mills, saw mills, etc. In the Geological Survey of Alabama Reports will be found a list of 987 utilized powers on Alabama streams.

It is therefore seen that this state is abundantly supplied with large water courses, with many beautiful tributaries having branches reaching every part of the commonwealth; and that numerous impounding basins have been constructed during the past century, mostly for manufacturing purposes, while more recently large dams have been built either to aid navigation or in connection with hydroelectric developments.

IMPOUNDED WATER IN RELATION TO PUBLIC HEALTH

The waters referred to in this paper are those caused to be temporarily stored by dams on Alabama streams, in which running water will always be found and by reason of which fact there is practically always a forward or downstream movement of the water impounded.

In the case of the pool above Lock No. 12 dam on the Coosa River—the back waters of which extend upstream about 30 miles—there is a complete renewal of the impounded water every five days during normal stages of the river.

Whether the effect of a dam constructed in any locality is to lessen or increase the healthfulness of the community contiguous to the

lake or pond created by the dam, is a question which can only be determined by careful topographical and biological surveys of the site and neighborhood before and after its construction. It is first necessary to ascertain the change in physical conditions before any conclusion can be arrived at. The primary purpose of the survey is to determine:

1. The influence impounded waters exert on the health of the surrounding community.
2. The conditions which affect this influence favorably or otherwise for good or for ill.
3. The measures to be taken to minimize deleterious effects and to increase to a maximum the beneficial effects.

The importance of the problem can be readily understood since it concerns the impounded waters of many of the large power and manufacturing plants now utilizing water power.

While nearly all of the litigation at present in the Alabama courts relating to the influence of impounded waters is in connection with the incidence of malaria, there have been many cases involving the pollution of water in ponds and of streams by emptying into them sewage, manufacturing wastes and mine waters.

In the *Southern Reporter*, volume 60, will be found the Alabama Supreme Court decision, January 16, 1913, in the case of *W. H. Hosmer vs. Republic Iron and Steel Company*.

Several years ago the Republic Iron and Steel Company built a small dam across one of the tributaries of the Warrior River, at a place called Greeley, in the northern part of Tuscaloosa County, to impound water for use at its ore mine. During the dry season there is very little running water in the branch on which this dam was built.

The facts made by the complainant are that, for a long time previous to the grievance complained of, he occupied and resided with his family, including intestate, who was his son, upon a piece of land near Greeley and that after plaintiff's residence and occupation upon said land had commenced, the agents and employees of defendant acting for it dammed up certain water and thereby created a lake of water near his residence, being so close thereto as to affect his health and the health of his said family, and the enjoyment of his residence. It is then alleged that defendant was engaged in the development of iron and other minerals, and had caused said lake or pond to remain there for a long time and had placed or caused to be placed in said pond various substances, which are named, and thereby caused or allowed said water or lake to give off and out foul and unwholesome

and noxious air and caused said premises on which plaintiff resided to become unhealthy, causing plaintiff's boy to become sick so that he died; and plaintiff alleges that said sickness was proximately caused by the wrongful act or omission or negligence of defendant as aforesaid in building, maintaining or constructing said pond. . . . The demurrers were that the cause of action did not survive to the personal representative and that the damages claimed did not survive. That there was nothing to show that plaintiff intestate was the owner of the land or had any possessory or leasehold interests therein; that the damages claimed were purely consequential and that no right of action was shown.

The Court held: The effect of the complaint is to aver that the death of the plaintiff's intestate, on account of which he sues, was caused by an issue of foul, unwholesome and noxious air from a pond which defendant corporation constructed in the neighborhood of his residence, where intestate, his minor child, lived with him. . . . We are not required to know how plaintiff will prove the causation alleged; but accepting the allegation as true and provable on demurrer, there will be no question but that it shows damage peculiar to intestate, not merely in degree but in kind. . . . It is obvious that to maintain an action for injury affecting the value of the freehold the plaintiff must have a legal estate. But if noxious vapors and the like cause sickness and death to one who has a lawful habitation in the neighborhood, no sufficient reason is to be found in the accepted definition of nuisance nor in the policy of the courts which would discourage vexatious litigation, nor in the inherent justice of the situation, as we see it, why the person injured, or his personal representative in case of death, should not have reparation in damages for any special injury he may have suffered, although he has no legal estate in the soil. Certainly a child has the right to live under his father's roof—is a lawful occupant of his father's home and in our opinion he should be accorded the same measure of protection against the construction of nuisances in the neighborhood which are so noxious and long continued as to materially affect his physical well being. . . .

In the building of dams and the impounding of water for manufacturing purposes in this state, except in saw mill projects, it has not been considered worth while to even remove saw timber within the submergence areas. Experience has shown that in a year or two after submergence or partial submergence the timber dies; the limbs and tops first fall and with the seasonal floods are carried away. Within a few years the trunks fall and disappear in the same manner. Thus by these natural processes the areas of these impounded waters are cleared, and the banks below the normal water level are made free from vegetation. These conditions may be observed in all parts of the state.

About six miles west of Troy, on the south side of the Atlantic Coast Line Railway, there was built about five years ago a fish pond, by impounding the waters of Mill Creek. At the dam the pond is

approximately a quarter of a mile in width, and the pool extends upstream for a distance of about one mile. The timber, of which there was a considerable amount of second-growth pine, was allowed to stand. All the partially submerged timber except a little bay and magnolia died during the first summer after submergence, and most of the timber has fallen. The pond is not an attractive place from an aesthetic viewpoint, but for fish it is excellent. There are some places around the fringes of this pond where the water backs over flat surfaces producing conditions favorable for the breeding of mosquitoes, but the relative area of these overflowed places is very small compared with the large areas of swampland permanently submerged by the pond. This pond has resulted in the creation of a combined pleasure and health resort out of what was formerly a malarial swamp. In the building of this pond, as in all other projects for utilizing the waters of the state, the question of effect upon public health was not raised until the suits against the Republic Iron and Steel Company were filed, of which mention has already been made.

In 1910 the state of Alabama began the construction of a dam across the valley of Mortar Creek, at Speigner, Alabama, at which place is located the state cotton mill operated with convict labor. The state owns about 3500 acres at Speigner, and the Mortar Creek bottoms include about a thousand acres of the state property. These lands were covered with a dense growth of timber, little of which was suitable for manufacturing purposes, and the lands even if cleared would not have been suitable for cultivation, being for the most part swamp and overflow lands. This tract being located practically in the center of the state's property was a menace to the health of the community. It was a veritable mosquito heaven.

A dam nearly a mile in length across the valley has been completed and a lake of 800 acres in area created. All the standing timber within the submerged area has been removed. The power created by this development is now being utilized to operate the electric light system, water works plant, grist mill and for part of the year to operate the cotton mill. The work was all done with convict labor. The permanent submergence of those 800 acres of swamp land has added greatly to improved public health conditions in that vicinity.

In order to be able to carry the water level of the Speigner dam to the desired height, it was necessary for the state to acquire about 75 acres of privately owned lands. Being unable to negotiate for

these lands, condemnation proceedings followed. The state contested the price fixed by the commission for the condemned land, on the assumption that the land appropriated was waste and uncultivable property, and that the remaining portion of contiguous lands would be increased in value by reason of the state's constructions, being made more healthful and habitable. In this view, the state health officer concurred, and was a witness for the state.

In the canalization of the Tombigbee and Warrior Rivers the United States government has built in all 17 locks and dams. Lock No. 1 is located on the Tombigbee 111 miles above Mobile, and Lock No. 17 is located on the Black Warrior 388 miles above Mobile. The backwater above Lock 17 extends up the Locust Fork of the Warrior to a point 425 miles above Mobile, and on the Mulberry Fork to a point 444 miles above Mobile, the confluence of these forks being 408 miles above Mobile. In addition to the pool extending 53 miles up these two main forks of the river, the backwater above Lock No. 17 extends up small tributary streams for a total distance of about 20 miles. The total distance, or length of the pool above Lock No. 17 created by the 63-foot dam, is 93 miles. Outside of the natural banks of the river and its tributaries, about 3500 acres of land has been submerged. In the construction of this lock and dam no effort has been made by the government to cut the timber that has been submerged.

In all the improvement work on the Tombigbee and Warrior Rivers, the only timber removed was that which might obstruct navigation. This is the same policy that has been followed in the construction of the Panama Canal.

So far as records are available, and from the testimony of many physicians whom the writer has interviewed, the year 1900 was the most unhealthful along the Warrior River from Tuscaloosa to Demopolis. In the late summer of that year malaria was epidemic not only along the Warrior and Tombigbee bottoms, but extended far back into the neighboring country and higher lands. Malaria prevailed in fact in all parts of the state.

At that time there were no completed locks. The dams were in course of construction, but the waters in both rivers had an unobstructed flow. During the summer there were two exceptionally high stages of the rivers, causing streams everywhere in the state to overflow their banks, and to spread over vast tracts of land in the Coastal Plain. The heavy rainfall of that season undoubtedly cre-

ated numerous favorable breeding places for mosquitoes, which ordinarily do not exist.

Assuming that the unprecedented rainfall of the summer of 1900 explains the unusual amount of sickness in the autumn of that year, yet the fact remains that since these two rivers have been completely canalized, there has been less and less malaria each succeeding year, and the health conditions along both rivers have steadily improved.

The impounded waters in the Birmingham district include a reservoir on the Five Mile Creek and a reservoir on the Little Cahaba River which are used as sources of supply by the Birmingham Water Company and are estimated to have during drought a combined capacity of 42,500,000 gallons per day. An excellent system of treatment and filtration is employed before these waters are served to the public.

In addition to the above reservoirs, the Tennessee Coal, Iron and Railroad Company built for manufacturing uses an impounding reservoir on Village Creek near Ensley, capable of furnishing daily 50,000,000 gallons in dry seasons. Artificial lakes have also been built at East Lake and West Lake near Birmingham. The sites of all these impounding basins were cleared of standing timber to the water line before submergence.

Tuscaloosa is the only city outside of Birmingham in Alabama drawing its public water supply from a large impounding basin, the supply being obtained from the pool caused by Lock No. 12 Warrior River.

When the Spring Hill pumping station of the Mobile water works was built in 1900, a dam across Three Mile Creek was constructed, which created a shallow pond submerging several acres of dense vegetation. Superintendent M. F. Sullivan in his report, dated Mobile, March 15, 1915, says:

In my report to the mayor and general council on May 15 I recommended that the dam across Three Mile Creek at the pumping station be opened up and a new spillway be constructed, the crest of which would be on the same elevation as the normal water surface of the creek, thereby eliminating the pond feature of our water supply, as same had not been cleared of all vegetation, top soil, etc., and the capacity of the creek being sufficient to supply the future demands for several years, no storage of water was necessary. But before anything was done in the matter the unprecedented rainfall of June 26 (12.67 inches in 24 consecutive hours) caused an enormous rise in the creek, and the 50-foot spillway provided for the escape of only a small portion of the storm water, and as a result the water soon washed out about 150 feet of the dam and also the old spillway.

The above enumeration covers the list of impounded waters in Alabama. It will be seen that only two cities derive their public water supply from impounding basins and these supplies are mechanically treated before being used.

The relationship of impounded waters in Alabama to public health is therefore limited to the influences they may have other than through water borne diseases such as typhoid, para-typhoid or paracolonic fevers, cholera, etc., and may be studied in their relationship with reference to

1. Humidity and changes in hygrometric conditions.
2. As a source of foul or deleterious odors.
3. As breeding places of mosquitoes.

The complex relations of humidity and evaporation make it practically impossible to compute, with any degree of accuracy, evaporation over an extended surface of a water shed or drainage area—or to ascertain the effect on humidity in the various river basins, due to the comparatively minor changes in the surface conditions caused by clearing of timber lands or adding to the exposed water surfaces by the construction of impounding basins. The average annual relative humidity from Mobile to the gulf is over 80 per cent and for the rest of the state from 70 to 80 per cent. A given air space at a given temperature can contain only a definite amount of water. If it contains less it will endeavor to fill up by evaporation; if it contains more the surplus moisture will condense. The higher the temperature the more moisture it takes to saturate the air.

The experiments of Desmond Fitzgerald on evaporation from water surfaces (see *Trans. Am. Soc. C. E.*, vol. xv, p. 581) show that evaporation depends upon three elements: The vapor pressure corresponding to the temperature of the surface of the water; the vapor pressure corresponding to the dew point of the atmosphere, and the velocity of the wind.

For the five months, June to October inclusive, the probable average daily evaporation from exposed water surfaces in Alabama is about 0.16 inch and the average rainfall throughout the state approximately equals in depth the amount of evaporation from the water surfaces for the year.

Since the absolute humidity decreases rapidly from equator to the poles but decreases more rapidly in the interior of the continents than over the oceans, it is evident that even the relative humidity in any section of the state which is highest at night and lowest in

the hottest part of the day, can be but slightly influenced by changes in the areas of natural water surfaces since these areas are insignificant compared with the ocean surfaces from which the atmosphere draws its chief supply of moisture. Furthermore the areas of the water surfaces of the impounded streams in many of the canalization projects have been but very slightly increased because of the steep natural slopes of the banks. The total areas of these impounded water surfaces compared with the land areas are exceedingly small. It is therefore evident that the impounded waters have little or no effect upon the normal humidity or atmospheric conditions in their vicinity.

2. (a) As a source of foul or deleterious odors, impounding reservoirs will be considered into which vegetable, animal or mineral matter is transported as in the Village Creek reservoir of the Tennessee Coal, Iron and Railroad Company already referred to and a more complete description of which will be found in the article on "Water and Air Movements," by Mr. W. F. Wilcox (PROCEEDINGS OF AMERICAN WATER WORKS ASSOCIATION, 1913, p. 310). When this reservoir was originally planned, fears were entertained that at some

future time it might become so filled with putrescible matter as to be objectionable, causing sickness to the adjacent population. It was therefore determined to take all possible precautions during construction, and to keep daily observations of all physical conditions and to make periodical examinations.

A pipe line 8 miles long was constructed to remove waste from a by-product plant; a sewage disposal plant was put into service to treat sewage reaching the reservoir and at coal mines and washers settling arrangements were constructed; from the reservoir basin vegetable matter was removed before the water was impounded. These precautionary measures were undertaken because this impounding reservoir is strictly a conservation proposition and during periods of drouth there will be a considerable draw-down on the basin and no overflow. The waste from the by-product plants and mines carried around this reservoir, empty into Village Creek below the dam and are emptied through this creek into Locust Fork in the pool created by the dam at Lock No. 17 Warrior River. This last mentioned impounding reservoir is the largest in the state and receives into its waters the manufacturing wastes of the Birmingham

district, the mine wastes of the Warrior coal fields, the vegetable and animal wastes of a drainage area of approximately 4000 square miles and the human wastes of a population of about 200,000. Notwithstanding all these polluting influences the pool caused by Lock and Dam No. 16 immediately below this pool has never emitted foul odors except during the first fall season after its completion; the odors at that time being due to the decomposed land flora which had been submerged in the reservoir itself.

It is likely that the same odors from decomposing vegetation will be noticed this fall around the margins of the reservoir caused by Lock and Dam No. 17.

So far as records are available, the impounding reservoirs in this state, into which animal, vegetable or mineral matter is transported, have not been the source of foul or deleterious odors, except when the waters were first impounded.

(b) Whipple says (*"Microscopy of Drinking Water,"* p. 186): "Almost all surface waters have some odor. Many times it is too faint to be noticed by the ordinary consumer, though it can be detected by one whose sense of smell is carefully trained." This statement is undoubtedly true with reference to the impounded waters of Alabama during the late autumn, when decaying vegetation of the catchment and on the littoral is carried into the reservoirs. These odors may be unpleasant occasionally, but in the basins herein considered by reason of the dilution due to the large bodies of water, the almost constant forward or downstream movement of the waters, and the frequent rains causing freshets, the odors can not be said to be especially disagreeable or offensive. It is not conceivable that these odors could in any way be detrimental to public health.

3. As breeding places for mosquitoes.

MALARIAL FEVERS

Prevalence and Geographic Distribution in Alabama

The first available statistics which were studied were of the admissions of cases into the United States Marine Hospital at Mobile during the 10 years 1902 to 1911, inclusive. (See Public Health Reports, vol. XXVII, No. 52, Dec. 27, 1912, by Surgeon R. H. von Ezdorf.) Available statistics at the office of the Alabama State Board of Health begin with the year 1910, but are quite imperfect for the years 1910-1913 inclusive. This incompleteness of records is due to the failure of the physicians of the state to make the reports. In his 1912 report Surgeon von Ezdorf arrives at the following conclusions:

1. All forms of malarial fevers prevail in the state of Alabama.
 2. Morbidity reports indicate that in September, 1912, about 1 person for every 50 population suffered an attack of malarial fever, and during October 1 person in 67 had an attack.
 3. The types of infection, in order of preference, are: Tertian, esto-autumnal and Quartan.
 4. The chronic type of malarial infection is proportionally greater in the colored race than in the white.
- In every county in the state the reports state that there are swamps or poorly drained lands. Mosquitoes were reported as present in all counties for which information was given on the subject.

The same authority (see *Public Health Reports*, vol. 29, No. 18, May 1, 1914,) states that

The regions in the state in which malaria prevails to the greatest extent are apparently in the Tennessee Valley belt, which extends across the northern part of the state, and also in the central prairie region known as the "Black Belt."

The morbidity reports indicate that the disease exists in every county in the state, the tertian type being most prevalent.

The reported deaths from malarial fevers total 434 for the year 1913, which is equal to 2 per cent of the reported deaths from all causes, and is at the rate of 20.3 per 100,000 population.

The United States Public Health Service is now engaged in an investigation of the prevalence and geographic distribution of malarial fevers in the states of Alabama, Arkansas, Mississippi, South Carolina, Georgia, Florida, North Carolina and Tennessee. For the year 1913 cases were reported from every county in the states of Arkansas, Alabama, Mississippi; all counties in South Carolina and Florida, except one in each state, from which no reports were received, and in 138 counties of the 148 in Georgia. August and September are the months of greatest prevalence in all these states.

MALARIAL SURVEYS

The United States Public Health Service made malarial surveys in selected localities during 1913 in the states of Arkansas, Alabama and North Carolina, in which the topographic and climatic conditions of the locality, and social, hygienic and economic conditions of the communities and industries were studied. (See Reprints Nos. 156, 160, 172 and 193 from *Public Health Reports*.)

Dr. H. R. Carter, Senior Surgeon, United States Public Health Service, in charge of the surveys in North Carolina, read a paper on

"The Effect of Impounded Water on the Incidence of Malaria" before the meeting of the Southern Medical Society at Richmond, Virginia, November 9, 1914, in the introduction of which he says:

Last fall a new problem was presented to me—the effect of large bodies of impounded water on the production of malaria. It was interesting; it was important and it was new. . . . Of its importance there can be no question, as it is especially concerned with the large ponds of the power plants of the South; to which plants this country is looking for no little part of its future development. I was looking over a map of the Southern Electric Co. and a reasonable estimate of the cost of the plants there given as in operation would exceed \$150,000,000 and as many projected. . . . If these plants, or rather the ponds of these plants, are a serious menace to the health of the community, either they must not be allowed, or can only be allowed by rendering unhealthful, or even uninhabitable, a considerable area adjacent to them. In either case the loss involved is a very serious one, and the problem is certainly new.

Dr. Carter's paper read at Richmond and his report to the government published in *Public Health Reports*, vol. 29, No. 52, December 25, 1914, on "Impounded Waters," were the pioneer papers on the subject, contributing largely to our present knowledge of the effect of large bodies of water confined by artificial structures on public health, and indicating the character of surveys and investigations which should be made to obtain a broader knowledge of the subject.

A study of the impounded waters on the Coosa River in Shelby, Chilton, Talladega and Coosa Counties, Alabama, was made by Mr. J. A. Le Prince, sanitary engineer, United States Public Health Service, during the months of October and November, 1914 (see Reprint No. 257 from *Public Health Reports*), also of the same reservoir by Mr. J. V. Donley, Sanitary Engineer of the Board of Health of Alabama at the same time the investigations were being made by Mr. Le Prince. (See "Impounded Waters," by J. V. Donley, *Board of Health of Alabama Report*.)

During the period of the above investigations (October and November, 1914,) the writer spent about two weeks with local physicians in the same counties, making a special investigation of the sanitary conditions not only in the neighborhood of those homes near the reservoir but in many cases distant several miles from the pool.

The investigations which were inaugurated in the fall of 1914 will be continued during the present year by the United States Public

Health Service and doubtless by the State Board of Health of Alabama, with the object of determining (1) the influence of such waters on the incidence of malaria; (2) what conditions affect this influence for good or for ill; and (3) what measures can be taken to minimize the ill effect of such waters and to increase to a maximum their good effect.

The investigations during the fall of 1914 and those which are now proposed by the United States Public Health Service on the Coosa River basin, were doubtless inspired by the numerous suits (700) filed in the four county and circuit courts in which the reservoir is situated, for alleged damages due to the creation of this lake above Lock and Dam No. 12.

Since the dam was built in strict conformity to plans approved by the war department, the pool created by it becomes part of the national government's project for the improvement of navigation on that river, the power company incidentally utilizing the power created by the dam, has no authority in any way to change the level of the lake determined by the crest of the dam now built, except in so far as it may be permitted to draw down the lake level to a point that will not interfere with navigation or the operation of the locks when installed.

Mosquitoes

It has been proven beyond a doubt that:

1. Mosquitoes carry malaria from man to man.
2. That the disease can be contracted in no other way than by being bitten by malaria-carrying mosquitoes.

Just how many kinds of mosquitoes there are in the world today nobody knows. Distributed as they are, there are large areas in which the mosquito fauna is not known, and will not be for years to come. One of the greatest authorities (F. V. Theobald) states that the number of species will not be less than 1000. At present the known species are grouped in about 50 genera. Male mosquitoes, with probably rare exceptions, do not bite—only the females do.

The most common mosquito in Alabama is the *Culex impiger*, or common house mosquito, which has been reported from Alaska and is found in all the Southern States.

The *Stegomyia calopus*, or yellow fever carrier, is universally distributed over Florida and probably Alabama, having been identified

in 14 counties in 1913 from specimens received at the Marine Hospital at Mobile.

Everybody knows that the mosquitoes of the genus *Anopheles* are responsible for the transmission of malaria. The *Anopheles punctipennis*, the most common species in Alabama, is not however a carrier, or has not to the present time been shown to be a carrier. The *A. quadrimaculatus* and *A. crucians* are probably the chief carriers in Alabama.

Breeding Places of Anopheles

All mosquitoes breed in water and in Alabama probably at all times during the year, the intensity of development corresponding to temperature conditions, the greatest activity following the high temperatures of the late summer and fall. A study of the topography of Alabama shows there are breeding places in all parts of the state which may be designated as those of a "constant" and those of a "temporary" character. Those of a constant character are places found along poorly drained creeks, cane and cypress brakes, marshy places in woods and along river banks, ditches containing water at all seasons with grassy banks. The marshy places about springs and along small branches and creeks with wooded and grassy banks probably furnish the most favorable conditions for breeding even during the winter months. In such places larvae of the *Culex* and *Anopheles* were found in November and in February of the present year. On April 11 larvae of *Culex* were procured in great numbers in a spring fed grassy pool in a ravine near Lock No. 10 Warrior River, some of which hatched on April 18. Larvae from another pool near by obtained by the writer on April 14, hatched on the 19th of April.

It is evident that in these protected pools eggs or larvae have been present during the winter as well as mosquitoes in the immediate vicinity. The protection of the wooded grounds, evergreens and warmth of the spring waters, make such places ideal winter resorts and permanent abodes for the mosquito. The pools above mentioned are certainly complete breeding places, i.e., places developing imagos from eggs deposited at that place.

Temporary breeding places are found in poorly drained ditches, gutters, barrels, tin cans, bottles, hoof-prints of stock, pools in roads, or in water courses that dry out in a short time unless refilled. Such places may become for the time being a complete breeding place.

A place may be designated as incomplete when, although eggs are deposited there, yet imagos are not there developed from them, as in a creek or river completely scoured out by a freshet, all larvae being removed and either drowned or carried elsewhere. Such a creek may supplement an incomplete breeding place as a bayou or the backwater at creek's mouth transporting larvae that find shelter in the floatage sometimes found in such places.

In the investigations by the writer in Shelby, Chilton, Coosa and Talladega Counties, Alabama, in October and November, 1914, *Anopheles* larvae were obtained at or in the vicinity of practically all of the homes inspected and it was only necessary to locate standing, quiescent water to find them. Specimens were obtained from many wells from which water was drawn by buckets attached to ropes, from springs in the hollow and on the hillside, in the marshes and quiet waters along the banks of rivulets and small streams, pools in roadways. In fact wherever quiet water could be found, except in occasional places that had been heavily oiled, specimens were obtained.

The shores of the Coosa River were carefully examined in many places. Only at springy places along the shores and above the lake level and at the mouths of creeks in the dead water or at the head of backwater in bayous were we able to procure larvae, few of which were *Anopheles*. At no place were we able to procure or to see larvae in large numbers.

The writer was strongly impressed from observations made at that time and since, that the large streams with their impounding basins are not the important breeding places of mosquitoes in this state. It is true that eggs and larvae are transported into these streams and a percentage, probably small, mature and survive. Some favorable places for breeding will be found such as have hereinbefore been indicated; but these areas are relatively small compared with the natural and complete breeding places that have been permanently submerged. The writer believes when the facts are better known and the problem is more fully worked out, malaria control will become largely one of local sanitation and drainage. Malaria will then be largely prevented or eradicated by measures applied at or near the home.

Natural Enemies

The deep waters, wave action and currents of the impounding reservoirs described make such waters unfavorable places for the

breeding of mosquitoes. In the larval and wiggler stage, they have many enemies; minnows eat them, the larvae of dragon flies, beetles or mellow-bugs eat them, "disease attacks them, fungi get on them and kill them;" they die for lack of food, they devour each other, they get entangled or under leaves and drown, the water dries up and in this way millions perish before they are grown. Many perish while emerging from the pupa by reason of the capsizing of the cast-off skin serving as a boat.

Those that do hatch successfully meet new enemies among dragon-flies, bats, lizards, toads, frogs, night hawks and a host of other enemies.

SURVEYS NECESSARY

United States Government Surveys

The purpose of the United States Public Health Service Surveys now in progress has been already described.

In connection with the construction of Dam and Lock No. 17 on the Warrior River field work and surveys had been carried out prior to the completion of that work as follows:

Bench-Mark levels from "mean-tide" Mobile Bay were established and extended from Lock No. 16 up the river beyond and above the backwater on both Mulberry and Locust Forks.

Complete topographical maps with 5-foot contour intervals were made from surveys covering the entire basin of submergence.

The surveys are usually made to the tops of river banks, but in some cases have only been extended for one contour above pool level.

Careful and detailed topographic and geological surveys of the sites for locks, dam and appurtenances which receive the careful study and investigation which their importance demands.

In making the traverse of the banks and bed of the Warrior and its tributaries, all lands liable to submergence were carefully mapped, tied in with section corners, and in many cases were photographed. Some cultivated lands have been submerged. Property of this kind received the most careful attention on the part of the government engineers, photographs being made of all structures, and of various divisions of the land, three photographs from different viewpoints being taken of each structure or piece of land.

Outside of the sites for dams and locks, the government purchases little land until after the completion of the work of actual submer-

gence of the same. Along the navigable streams the ownership of the banks is often a mooted question, because of the difficulty of establishing high, low and normal flow lines.

While it is the policy of the government to be fair and even liberal in its acquirement of such lands, frequently the small and ignorant property owner becomes the victim of unscrupulous lawyers and land grabbers. These rascals go to such owners and tell them that the government intends to submerge a large part of their land; that they can not sue the government, and that the balance of their land will be uninhabitable after the dam is completed on account of malaria, etc. By such misrepresentations lands have been recently sold around the pool created by the dam at Lock No. 17. These lands are all underlaid with coal, and in most cases the mineral value per acre far exceeds the surface value.

In view of the vast interests involved in connection with the construction of these impounding reservoirs, including the questions of public health, regulation of stream flow and navigation, utilization and conservation of natural resources, security for investors and all other economic questions, the importance of systematic physical and zoölogical surveys of the site and neighborhood of any proposed impounding basin must be apparent.

Such surveys have not been made in the past or in connection with any known basin so far as the writer is informed. Had such investigations been made before the building of a number of large dams in this state and in the Carolinas the litigation pending would have been avoided.

Dr. Carter says:

Since we wish to determine the whole effect of the pond on the production of malaria, we must compare the condition which existed before the pond was made with that which exists afterwards. If the malaria which the pond produces be counted a debit, the malaria it prevents must be counted a credit. It is the *change* in conditions we would know.

The physical survey should include all the field work required for the production of a complete record of the topographical, geological and botanical characteristics of the site intended to be submerged as well as the surrounding neighborhood.

The maps of these surveys should be made under the direction of an expert cartographer familiar with the methods of map construction and the conventional signs commonly employed. He should

be possessed of such actual knowledge of map making as is only gained by practical experience in field surveying of this class. He should be able to distinguish between the quality and value of the various symbols. These maps should clearly show the location of all pools, marginal wet lands or actual breeding places and the areas of such places together with the location of all temporary or permanent breeding places on tributary streams or neighboring lands.

The physical survey of the site should include careful investigations to determine whether the places examined are such as would make them favorable breeding places for *Anopheles*, and if so, are they so situated as to produce malaria; to determine what places are actually breeding malaria-vectors; to make a careful survey of all residences close enough to be influenced by any proposed constructions; the distances from such residences and any obstacles between the place examined and such residences; character of the water, vegetation, protection against wave action, floatage, proximity of blood supply, etc.

The Zoölogical Survey will take account of whether *Anopheles* or other mosquitoes are found breeding in any place and to what extent; the species of *Anopheles*, whether or not a malaria-vector; the presence of fish and other aquatic enemies; a careful study of and classification of *Anopheles* or other mosquitoes found about the premises of adjacent residences to proposed site and in the neighboring tributary streams or breeding places.

The sanitary survey should include a careful investigation of all health records of all people living in the community or within reasonable range of the proposed reservoir including blood examinations and a complete malarial index of the neighborhood or community. In this connection it is believed there will be little trouble experienced in securing the active coöperation of the board of health since the importance of these investigations is now so well understood.

DISCUSSION

MR. W. F. WILCOX: The speaker does not think discussion on the subject of "Impounded Waters" would be of any value to you unless you had at hand your data so as to show what the result was. We have a lake 7 miles long, varying in depth from zero to 80 feet. We keep close watch of this reservoir, having a chemist in charge who makes chemical analyses of the water, both mineral and bac-

teriological. We keep a record of the temperature of the water, taking this temperature at least once a week, also the humidity and the velocity of the wind.

One of the difficulties that we have to contend with is that at the head of the lake about 6,000,000 gallons of sewage empties. That sewage has been filtered before it is turned into the reservoir. The amount of purification that will take place in an impounding reservoir in such a case is remarkable. Our analyses show that as the water deepens and is allowed to run the purification is quite beyond our expectations. A discussion of impounded reservoir waters is not of any value unless you have detailed data. The speaker has such data for five years, and if any of you want any information at any time, he will be very glad to answer your questions; but offhand discussion without detailed data he does not think is of any value.

The speaker wishes to say that this reservoir that he has charge of is not for drinking water, it is for mechanical purposes; but we have been able to purify the water to such a degree that it meets the chemical and bacteriological standards. If it were not for the history of the water, we could easily palm it off as a very sanitary drinking water.

PRESENT STATUS OF DISINFECTION OF WATER SUPPLIES

BY FRANCIS F. LONGLEY

The treatment of water by disinfection has had a remarkably rapid growth and has come to be a popular and widely known subject. So much has been written and said upon this in the last few years that it is with some hesitation that the writer approaches the subject. In most phases of it there is danger of a great deal of repetition. There are a number of points, however, upon which recent occasion has arisen to make rather extended inquiry, and the following is intended to embody some of the results of this study.

This information was brought together through the circulation of a large number of inquiries intended to cover the field of disinfection in reasonable fullness. A list of the water supplies in the United States and Canada, in which some method of disinfection was known or believed to be used, was prepared from all available sources. Although the hearty coöperation of engineers, health officers and others was secured in a great many cases, there can be no assurance that the list was complete.

The total number of inquiries sent out was about 240. Replies were received to about 110, or nearly half. These replies represent in the aggregate water supplies of somewhat more than 2000 million gallons per day.

The information is given herein largely in statistical form, and, of course, relates only to the supplies regarding which replies were received.

Some of the inquiries were directed at the less used methods of sterilization, such as ozone and ultra violet rays, but so little information in reference to these was forthcoming that the writer is not disposed to say anything further in regard to them herein than that their development is not far enough advanced at the present time to justify the expectation of success in the near future which will permit them to displace the use of hypochlorite and liquid chlorine to any considerable extent.

Of all the replies received about 80 per cent are stated to use, or to have used, hypochlorite of lime, and the balance liquid chlorine.

About 75 per cent of the supplies regarding which information was received are river waters; about 20 per cent are from lakes, and the small remainder are ground waters.

The first application of hypochlorite noted among the replies was in 1908, in which year disinfection by this means was begun at the Bubbly Creek plant at the Union Stock Yards in Chicago; at the Boonton reservoir of the Jersey City supply, and upon the municipal water supply of Poughkeepsie, New York. The several years following showed a rapid increase in the number of installations, although the records of 1913 indicate a falling off. The rates for the year 1914 are incomplete. Of the total installations regarding which replies were received, the percentages installed each year have been as follows:

1909, 13 per cent, representing a total of 100 million gallons per day.

1910, 14 per cent, representing a total of 450 million gallons per day.

1911, 22 per cent, representing a total of 320 million gallons per day.

1912, 22 per cent, representing a total of 710 million gallons per day.

1913, 18 per cent, representing a total of 70 million gallons per day.

1914, 8 per cent, representing a total of 265 million gallons per day.

Some 37 per cent of the cities replying use a disinfection without other treatment. The balance use it as an adjunct to some treatment, in most cases filtration. In 57 per cent of those cases in which it is used as an adjunct to filtration, it is used as a final treatment. In 26 per cent it is used after coagulation or sedimentation and before filtration. In the remaining 17 per cent it is applied before coagulation and filtration.

The data at hand do not give any reasons for the application before coagulation. In general, an effective disinfection may be secured with a smaller quantity of hypochlorite if it is applied after rather than before filtration. It should be noted that the storage of chlorinated waters in coagulating basins and their passage through filters tend to lessen tastes or odors contributed by the treatment,

and this fact may in some cases account for their use in this way. Beyond this there is nothing in the moderate amount of bacterial data secured in connection with this work that enables us to generalize upon the relative advantages of these different points of application.

The cost per million gallons for the equipment required for this treatment varies widely and does not seem to bear any very close relation to the capacity. The cost per million gallons as stated, varies all the way from \$4 to \$2400. These variations are accounted for by the fact that designs for equipment of this sort vary widely. Some are the merest makeshifts, while others are elaborate. Some of the costs quoted include no building costs, while others include expensive structures. Taking the figures as they stand, as the data do not permit any further analysis, the total costs per million gallons are stated not to exceed \$25 in 12 per cent of the supplies, \$50 in 30 per cent, \$100 in 42 per cent, \$250 in 67 per cent and \$500 in 87 per cent of the supplies about which information is available.

The total cost per million gallons for the process also varies widely. By far the greater number of costs stated lie between 10 cents and 50 cents per million gallons, the average for these being about 25 cents.

The information at hand indicates that the commonest construction of tanks for hypochlorite is concrete. Some 67 per cent of the supplies stated that they had either concrete tanks or tanks of wood or iron relined with concrete. Something more than 20 per cent are of wood without lining. The balance are either wood with lead lining, wood or iron with some protective or acid resisting paint, or porcelain lining. The liquid chlorine is universally contained in special iron cylinders.

The piping seems in general to have been put together of the materials most easily available, without regard to corrosion. Fifty-six per cent of the replies indicate the use of iron pipe, either black or galvanized, 15 per cent use lead pipe and about an equal number use brass. A few use lead-lined iron pipe, cast iron pipe, hard rubber, rubber hose, bronze or copper pipe.

The same comments apply to the kind of valves and fittings commonly used. Sixty-six per cent of these are of brass such as are usually found in stock. Some 14 per cent state that bronze valves and fixtures are used, but it is possible that some, if not most of these, upon further inquiry, might prove to be brass. A few use

iron valves or fittings and a few have fixtures made of vulcanite, rubber composition, lead, copper, glass, etc.

The materials commonly used which seem to have shown the greatest resistance to the corrosive effects of hypochlorite are concrete tanks, lead pipe and rubber composition. Several of the answers indicate that copper, cast iron and lead-lined iron pipes are used without corrosion and a number indicate, too, that brass and galvanized iron are used without corrosion. The evidence as to these two last materials, however, is contradictory, as other answers indicate considerable corrosion with galvanized iron and brass. It seems likely that the quality of the material and some peculiar local conditions may, perhaps, be determining factors in the corrosive effect upon these two materials. The results show the unmistakable corrosive effect upon wrought iron and also upon wood.

Evidence has been found in the past of occasional large variations in the strength of commercial hypochlorite. In answer to an inquiry on this point, only 29 per cent indicated that the strength of hypochlorite as purchased had been determined. That this is a point of considerable importance is indicated by the following figures:

The maximum percentage of available chlorine stated was 42 per cent. Numerous others ran as high as 39 or 40 per cent. The minimum stated was 15 per cent, with several others less than 20 per cent. The average strength was 33 per cent. In two cases the maximum percentage strength noted is as large as $2\frac{1}{2}$ times the minimum strength. These variations in quality in the commercial hypochlorite are significant, and it is obvious that the strength should be determined and a correction made in the application, if necessary, if the best results are to be secured.

The low cost and the ease of application of disinfection to water supplies have caused its introduction in a great many places where the records of mortality or morbidity from such diseases as typhoid, which can be used as indicators of the benefits derived, are already so low that no striking improvement can be expected therein. In a large percentage of the cases it seems clear that the application was as a precautionary measure. This fact makes it less easy than might be expected from the large number of cities and towns making use of disinfection to present statistics showing actual benefits resulting therefrom. Among the large number of communities from which information was obtained, about 75 per cent failed to indicate that any improvement in typhoid or other health condition had resulted.

Many of these indicated that no such improvement had been expected. In some cases where there has been an improvement, it is difficult or impossible to discriminate between the effects of disinfection and of filtration.

The following statements show improvements that have resulted in a number of places:

In Cleveland, Ohio, the chlorination of the water supply started in September, 1911. In the six calendar years prior to this the typhoid death rates had varied from 13 to 20.2, with an average of 16.5 per 100,000. In the three calendar years following, the typhoid death rates were from 6.2 to 13.5, with an average of 9.2 per 100,000.

In Yonkers, New York, the analyst in charge of the water supply states that prior to the use of hypochlorite, but with the water filtered through sand filters, two epidemics of dysentery were recorded at times when the water was unusually high in bacteria. Disinfection by means of hypochlorite was put in use early in 1910. Since that time there have been no such excessive bacterial counts and no corresponding epidemics of dysentery.

In Evanston, Illinois, there has been an actual reduction in intestinal diseases, indicated by the statistics of typhoid fever and gastro-enteritis, which appears to have resulted from the application of disinfection. This was first applied in December, 1911. The statistics at hand cover the period of four years prior to this, namely, 1908 to 1911 inclusive; and three years after, 1912, 1913 and 1914. The death rate from typhoid in the former period varied from 24 to 33, averaging 29 per 100,000. In the period since disinfection it has varied from 6 to 15, with an average of 12. The death rate from gastro-enteritis during the former period varied from 25 to 73, with an average of 49 per 100,000, and in the latter period with disinfection varied from 11 to 40, with an average of 30.

In the city of Baltimore there has been a decided reduction in the typhoid mortality since the use of calcium hypochlorite. It was first used in June, 1911. In the five years prior to that, the death rate from typhoid varied from 33 to 42 per 100,000, with an average of 35. In the three years since, it has varied from 22 to 24, with an average of 23.

In Poughkeepsie the disinfection of the supply was first begun in 1908 in the form of hypochlorite applied to the water before sedimentation and filtration. The death rate from typhoid fever for eight years prior to 1908, as indicated by the United States census

reports, varied from 25 to 114, with an average of 54 per 100,000. From 1908 to 1913, with treatment as stated above, the typhoid death rate varied from 10.3 to 33, with an average of 18.5. Since early in the year 1914 the filter effluent has also been treated, first by means of hypochlorite, and latterly by means of liquid chlorine, and the death rate from typhoid fever for that year was 3.4 per 100,000.

Trenton, New Jersey, is one of the most striking cases of improvement due to disinfection. Prior to 1912 the city used the raw Delaware River water. In December, 1911, the authorities commenced to treat the water supply with hypochlorite. During the five years ending with 1911 the annual number of typhoid cases varied from 208 to 343, with an average of 267. During the three years since disinfection has been applied, the number of cases in the city has varied from 45 to 110, with an average of 74.

In Ottawa the water of the Ottawa River was used without treatment until about March, 1912. Its polluted condition was evidenced by the several epidemics of water-borne typhoid that the city had been through just prior to that. Since the disinfection of the supply, Ottawa has had no further epidemics and only a moderate death rate from typhoid.

The city of Hull, with only about one-twentieth the population of Ottawa, lying on the opposite bank of the river, takes its water supply, untreated, from the same channel as does Ottawa and within a few hundred yards of it. In two recent months Hull has had about 200 cases of typhoid fever, as against 28 in Ottawa for the same period.

In Centralia, Washington, during the winter of 1913 and 1914, there was a sharp epidemic of typhoid fever, due apparently to the pollution of a well supply by overflow of a stream which is known to have carried pollution. A hypochlorite plant was hastily installed and put in operation and this was followed by a quite definite and abrupt cessation of new cases of typhoid, since which time there have been no cases in Centralia, with the exception of certain hospital cases brought in from outside the community.

The results of hypochlorite treatment in Pittsburgh have indicated an improvement in typhoid conditions over and above that secured by filtration alone.

Hypochlorite was first applied in November, 1911. In that month there were 54 cases, in December 42, in January, 1912, there

were 20, and in February 5. From that time forward, the cases have remained for the most part less than 10 per month and have never again approached the high points of previous years. It is rare for the present high points to reach the former low points of the curve.

In Wilmington, Delaware, the excellent protection which disinfection affords was shown at the time of an epidemic of typhoid fever of about 250 cases at Coatesville, Pennsylvania, some 27 miles above Wilmington, upon the stream from which Wilmington draws its supply. The epidemic made its appearance in Wilmington, but was stopped short by the disinfection of the water supply.

The maximum dose of hypochlorite stated is 60 pounds per million gallons, which is at the Bubbly Creek plant in Chicago, where the nature of the water treated is well known to require a large dose. The lowest maximum quantity stated is 4 pounds per million gallons. The average of all the maximums stated for the various plants is 17 pounds per million gallons.

Bubbly Creek also shows the highest average dose of 55 pounds. The next highest is 35 pounds, and the lowest average dose stated is 3 pounds. The average of all the averages stated is about 11 pounds per million gallons.

Judging from the lack of information in response to inquiries bearing upon the relation between the quantity of hypochlorite required and the color or turbidity in the water, it seems that a surprisingly small amount of attention is given in the various cities to following out this relationship. A knowledge of this relation is of some importance, as it influences the quantity of hypochlorite that is required for a given water, the quantity that may be applied without producing objectionable tastes and the economy of the treatment.

The reason for the lack of attention to this point seems to lie in the fact that the cost of the hypochlorite required for any water is trifling and it is not of great importance just what quantity is applied, so long as it is enough, on the one hand, to give good bacteriological results, and, on the other hand, not so much as to produce objectionable tastes and odors.

The doses that fulfill these two conditions do not always coincide. The character of some waters is such that the dose which can be applied without contributing objectionable tastes and odors is more than enough to produce the desired bacterial reduction. With such

waters there is no difficulty in regulating the dose to give satisfactory results from every point of view. The character of other waters is such that the maximum dose which can be used without giving a taste is not enough to give the bacterial reduction required. This is the difficult condition to meet, and is found more frequently in raw waters than in filtered waters.

It is everywhere recognized that there are certain times when the hypochlorite treatment is less satisfactory than at others. This is shown principally in the appearance of tastes and odors that occasion complaint among consumers, or in a low and unsatisfactory removal of bacteria by the treatment. It occurs generally at a time when the turbidity or the color of the water increases greatly, or some other marked change, such as temperature, occurs in the condition of the untreated water.

Different waters vary a good deal in this respect, and but little information can be found which gives light upon the specific reasons for this variation and permits the formulation of general statements in regard to it.

An analysis of the figures at hand shows that in one place a maximum dose as great as 37 pounds per million gallons has not given rise to objectionable tastes or odors, and in numerous places 20 to 30 pounds has not been noticeable. The average amount stated for which no odor or taste was noticed was about 14 pounds per million gallons. The supplies in which it was definitely stated that no tastes or odors were noticeable included about 40 per cent of the total. Among the others there were general comments as to the occurrence of objectionable tastes or odors, indicating in the main that they are likely to occur with changes in the character of the water treated, especially at times of storm or freshet.

So far as is indicated by the somewhat incomplete data, the largest quantities of hypochlorite are used in those supplies in which the color or turbidity of the water are highest. Unfortunately, the information is not complete enough to enable any relationship to be established even in an approximate way between color, turbidity and quantity of disinfecting agents that may be used without objection.

DISCUSSION

MR. C. A. JENNINGS: About two years ago the speaker had a paper along the same lines before the Illinois Water Supply Association, and quoted statistics on typhoid death rates from a number of cities. The criticism was made of the paper at that time that the typhoid fever death rates were taken for periods anywhere from four to twelve years previous to the introduction of the disinfecting agent, and the typhoid data for only two or three years following—that is to say, whatever data were available since the introduction of the disinfectant were used. The point was made that great progress had been made in sanitation in the last few years, and that it did not give a fair comparison. If that criticism held in that paper it will also hold in Mr. Longley's paper. It may be well to weigh carefully the data received and not be too ready to place all of the credit to one charge. However, there is no argument against the statement that disinfection of water supplies has brought about a wonderful lowering of typhoid fever death rate, especially during the last four or five years.

MR. WM. M. JEWELL: The speaker has been very much interested in Mr. Longley's paper, and it seems that he has covered the statistics very well from a general standpoint, but he has not given the details that we need for laying out these works at various plants; in other words, the information is very general.

At Chicago, where the hypochlorite is used at one of the stations, it was found that about five or six times more hypochlorite was required for the sterilization than they could stand for, probably on account of the low temperature of the water; and that is a very important point that ought to be investigated by members of this section. It would be a good thing to have a committee on those features to report at the next meeting in order that the physical characteristics of introducing hypochlorite can be properly complied with. The members here would certainly like that information; those that are putting the plants in at least.

The paper states that the first use of hypochlorite was in 1908. In that connection will say that at the filter plant installed at the city of Adrian in 1897, the speaker used both hypochlorite of lime and sulphate of alumina, and prior to this chlorine gas was used on the testing plant.

Hypochlorite of soda and chlorine were first used on the Jewell filter at the Louisville Experimental Station about one year earlier, or in 1896; reference to Mr. Geo. W. Fuller's report of 1898 will substantiate this statement.

MR. M. B. LITCH: Will Mr. Jewell please state just what he meant by more than what the water could stand for?

MR. W. M. JEWELL: That is the statement that Mr. McDonough, the assistant commissioner of the public works, used, and presumably related to the odor, or the taste rather, if you can differentiate between the two in the case of hypochlorite of lime any more than you could with peppermint. He stated that at times of low temperatures the hypochlorite seemed to be undecomposed, and that therefore they could not get rid of the Coli; the amount used was five or six times more than was required under ordinary conditions of normal temperature at which times excellent results were obtained and the odor or taste, if any, would not be noticeable. Possibly there is a point, probably somewhere below normal temperature of the lake water, where the hypochlorite can be used efficiently and no odor or taste imparted to the water; whereas on the same water at a slightly lower temperature, such objections would exist and cannot be combated; at least in the light of our present knowledge of the way of using hypochlorite.

MR. H. P. LETTON: In 1911 Trenton, New Jersey, began to treat raw Delaware River water with hypochlorite. The state board of health carried on a series of examinations for the purpose of determining the proper dosage. At that time, which was during the winter, the water was cold and very high in turbidity and organic matter. The dose of chemical added was run up as high as 30 pounds per million gallons. Samples of the treated water taken an hour after the addition of the chemical, and tested for free chlorine, all gave negative results, although the water had an extremely disagreeable taste, and this taste persisted throughout the entire distribution system, and was especially noticeable in the hot water. The steam arising from a flowing hot water tap had a very strikingly unpleasant odor. From the tests made the conclusion was reached that the taste and odor were not those of the chlorine, but were due to some complex chemical change brought about by the action of the chlorine

on the organic matter present in the water. There was more or less complaint about the taste and odor at the time, but, as Mr. Longley's paper has shown, the chlorine treatment at Trenton reduced the typhoid death rate to a remarkable extent. A report on the tests mentioned and some statistical data regarding the effect of the treatment will be found in the 1912 report of the New Jersey state board of health.

MR. R. L. SACKETT: In the state of Indiana there is quite a wide variation in the geological conditions, which has permitted the smaller cities in the northern part to use well waters, but in the southern portion well waters are rare, and they have therefore quite generally used the surface waters of the Ohio River Valley. These waters are polluted in greater or less amounts. Some cities in Indiana have for several years been using water supplies for fire protection and street sprinkling purposes only, and not using them for culinary purposes. The state board of health found a portable apparatus for the installation of hypo treatment to be very valuable, and have equipped their laboratories with these simple temporary pieces of apparatus, which can be sent out to the smaller cities, and there hypo has been used, too much at times, and undoubtedly at other times too little, in cities where the water supply was without treatment at all, or where it was not satisfactory. These plants are inexpensive of course. They are manually controlled, and the question of the cost of hypo was not important. Very frequently the odor and taste of hypo were objectionable, but not so objectionable as the conditions which preceded it, and unquestionably this plan of the state board of health of placing in cities, practically without expense, as a temporary measure, these simple schemes for treatment with hypo has been of great value.

It is very difficult to collect data concerning the absolute influence upon mortality and morbidity, but the state board of health has been pretty well satisfied with its little propaganda, and feels that it has been of value. Many of these smaller cities have very gratefully accepted the tastes and odors as being the lesser of the evils until they could install better apparatus for the protection of their water supply.

MR. JOHN A. KIENLE: Mr. Jewell's remarks regarding the effect of the temperature of the water at Chicago producing taste and

odor recalls to the speaker's mind the conversation with the gentleman mentioned by Mr. Jewell, namely, Mr. McDonough, assistant mechanical engineer of the department of public works, and the speaker wishes to throw a little light on this subject.

In conversation Mr. McDonough stated that when the temperature of the water is down around 38° or 40° they are compelled to materially reduce the amount of hypo being applied. However, on numerous occasions, it was stated that the taste and odor prevalent in the city tap water were not due to an excessive quantity of hypochlorite actually being applied. In Chicago the application of hypo is made at the intake cribs, which are located a considerable distance out in the lake and the direction of the winds, as well as the state of the lake, due to these winds, necessitate the holding of the sludge in the tanks for a considerable length of time. This sludge sometimes accumulates to such an extent that they are compelled to dispose of it even under adverse conditions. At such times the action of the waves and the winds causes this sludge to be blown back into the crib and down into the shaft and tunnel. The result is a very noticeable taste and odor in the tap waters of the city fed from these particular cribs with the natural complaint from the citizens.

The writer believes that quite a little of this sort of trouble in Chicago has been due to the fact that close supervision could not be given to the operation of the hypo plant. In some instances there is not even telephone communication with the cribs. Under these conditions it is naturally to be expected that the attendants in charge of the hypo treatment are not familiar with the conditions prevailing in the city, and therefore cannot be quickly advised as to the best amount of hypo to be applied.

The question of temperature of the water also has its effect in other places; this being particularly the case at Milwaukee where the speaker is familiar with the operating conditions. In this city they normally apply during the spring, summer and fall months of the year, about six pounds of hypo per million gallons, but as soon as the water temperature goes down to about 40° they are compelled to cut the dose applied to as low as 3 pounds per million gallons; this being necessary in order to prevent taste and odors prevailing in the tap waters. At the times when this decreased dose is applied the bacteriological count runs up considerably and it is due to this fact, as well as the desire to prevent taste and odor, that

the use of liquid chlorine was recommended and a liquid chlorine plant recently installed.

It is rather difficult to give an absolute reason for the prevalence of taste and odor in these low temperatures following with application of hypochlorite of lime, except that it may possibly be due to the nondecomposition of the chloride solution. This is a chemical compound and it naturally has to be broken down in order to accomplish its bactericidal action, and if it is not broken down then the chlorine is carried right through with the lime and is undoubtedly responsible for the taste. It is a known fact that chloride solution will not readily decompose in water at low temperatures.

The question of organic matter affecting the taste and odor, the speaker believes is one that should be given careful consideration. In a great many cases where taste and odors prevail they are due, not to the liquid chlorine or to the hypochlorite, but to the decomposed vegetable or organic matter in the water. This was the case at East Chicago and the speaker knows of other similar instances, and he further believes that the nature and character of the organic matter in the water also have a decided effect on this question of taste and odor.

As an example he would cite the following: At the Notre Dame de Grace, District of Montreal, they have a rather peculiar condition of this kind. The water at this station is taken from the St. Lawrence River just below the junction of the Ottawa River with the St. Lawrence. During the winter months nothing but St. Lawrence River water reaches the intake of the station, yet when the spring freshets prevail the Ottawa River water rises very materially and the current from it is swept across the St. Lawrence into the intake of the pumping station. The Ottawa River is of an entirely different character from that of the St. Lawrence. It is a water that is quite high in color and in organic matter. It does seem, however, that the nature of this organic matter must be quite different from that which would be found in other waters. This is evidenced by reason of the fact that at this station they are applying liquid chlorine and when treating the St. Lawrence River water approximately four-tenths parts per million of available chlorine are required for sterilization. As soon as the Ottawa River water reaches the intake they are compelled to apply as much as one and one-half parts of chlorine per million, yet even with this high dose no taste or odor prevails.

In the operation of this plant sufficient chlorine is applied at all times to the intake so that they get a KI reaction on a sample of tap water taken from the discharge of the pump. The liquid chlorine, however, appears to be entirely dissipated by the time it has traveled several hundred feet from the station as no KI reaction can be obtained on samples taken at this point.

DR. D. P. CURRY: At Bowling Green, Kentucky, there were tastes and odors. At the plant they had but one mixing vat. The operator would start his pump and stirring device at the same time, pumping the sludge and all into the mains. At that time they were doing some work on the mains, and there was considerable disturbance of the sediment in them. The odor and taste of the hypo were extreme. Was not this due to using the milky mixture rather than the sedimented clear solution?

MR. JOHN A. KIENLE: Regarding the last gentleman's remarks the speaker would say that at Pittsburgh they are applying the hypochlorite powder directly and in a very crude way and so far as he knows excellent results have been obtained without the prevalence of taste and odor. In other words, at this plant they do not attempt to take out any of the sludge or even settle it. The application is made simply by shoveling the powder into the water of the clear well at regular intervals. This therefore is one instance where the sludge does not worry them apparently.

MR. H. P. LETTON: The speaker knows that a year or two ago the East Jersey Water Company, at their filtration plant at Little Falls, New Jersey, treated the filtered water with hypochlorite, which was fed in as a milky solution, the lime being kept in suspension by a stirring device. No tastes or odors resulted from this practice.

THE MANUFACTURE OF SULPHATE OF ALUMINA AT THE COLUMBUS WATER SOFTENING AND PURIFICATION WORKS

BY CHARLES P. HOOVER¹

A plant for making alum has recently been built and put in service at the Columbus water purification plant. This is the first plant of its kind ever built at a water purification works for making alum to coagulate water, and, although it has only been in operation a short time, it has been a success both technically and economically.

An investment of \$12,000 was required for its construction, and it has been conservatively estimated that \$6000 per year will be saved the city in the cost of alum. Between 800 and 1000 tons of alum will be manufactured during the coming year at a cost of about \$10.50 per ton.

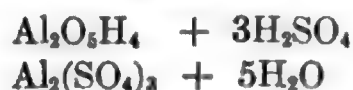
The process most generally employed today for coagulating and purifying water contemplates applying to the water under treatment a solution of aluminum sulphate prepared by dissolving in water the previously crystallized chemical.

In order to show the advantage of the new process, as used at Columbus, and to point out the advantage of making alum at the point where it is to be used, a brief explanation of the old process of making alum for water purification purposes will be necessary.

OLD PROCESS FOR MAKING ALUM FOR WATER PURIFICATION PURPOSES

Lump alum or sulphate of alumina is a combination of bauxite (a southern clay containing from 58 to 60 per cent alumina, the aluminum being present $\text{Al}_2\text{O}_3\cdot\text{H}_2\text{O}$) with sulphuric acid (H_2SO_4). By mixing the two in lead lined tanks, and boiling for a period of from 6 to 8 hours, the first step in making alum is taken.

The following reaction takes place between the bauxite and acid.



¹ Chemist, Columbus, Ohio, Filter Plant.

The resultant solution is a mixture of aluminum sulphate and silica, and in order to obtain the clear aluminum solution it is necessary that the mixture be filtered.

The filtering process is perhaps the most costly, tedious and annoying step in the whole process of alum making, because the finely divided particles of silica present in crude sulphate solution quickly clog the pores of the filtering medium, and it is often necessary to force the material through the presses under considerable pressure. After being filtered the alum solution is boiled to expel the excess water. The expense of concentrating the syrup must be taken into consideration, because it is concentrated from a density of between 25° and 30° Baumé to a density of between 58° and 60° Baumé. After being concentrated the solution is discharged into trays, and, on cooling, crystallizes to the alum cake. The alum cake is then crushed or pulverized and shipped either in bulk, in barrels, or in sacks. The material, after being received at a water purification plant, is usually dissolved as needed, and a standard strength solution prepared, this solution being fed by a suitable measuring device into the water to be purified or treated.

THE HOOVER PROCESS

Bauxite and sulphuric acid are boiled in lead lined tanks until a basic solution of aluminum sulphate is obtained. The solution is then diluted with water, usually enough water is added to make 500 gallons of the solution equivalent to one ton of 17 per cent Al_2O_3 alum, and measured as needed into alum solution tanks, where it is diluted with sufficient water to make a standard solution, which is then applied to the water under treatment. By this process five distinct steps in alum making are eliminated, namely, filtering, concentrating, crystallizing, grinding and redissolving. This process is a much shortened process, being simple and inexpensive, because it consists simply in boiling bauxite with sulphuric acid and applying the resultant solution to the water under treatment.

DEPOSITION OF SLUDGE OR CHEMICAL MUD

The crude alum solution containing silica or other inert material from the bauxite, probably better defined as chemical mud, is applied to the water under treatment, the chemical mud mixes with the mud or suspended particles present in the water and finally be-

comes entrained or coagulated by the precipitated aluminum hydrate and settles out in the settling basins. The crude solution, containing the chemical mud in suspension until the metallic sulphate has been converted into hydroxide, has a function not possessed by alum solution prepared by the old process, namely, forming a matrix or nucleus for starting the coagulation, resulting not only in more efficient results with less coagulant, but also affording the process universal applicability irrespective of any lack of natural turbidity.

BAUXITE²

The first discovery of bauxite in America was in 1887 at a point a few miles southeast of Rome, Georgia. At present the known workable deposits of bauxite are limited to a few localities in Europe and the United States. Its occurrence in Europe is in France, Germany, Austria and Ireland; and in the United States, in Georgia, Alabama, Arkansas and New Mexico.

The mining of bauxite in the southern states has shown a great growth during the last few years. The annual production passed the 150,000 long ton mark in 1911. The production of bauxite in the United States from 1900 to 1911, inclusive, is shown in the following table.

YEAR	GEORGIA AND ALABAMA	ARKANSAS	TOTAL	VALUE
1900	19,739	3,445	23,184	\$89,676
1901	18,038	867	18,905	79,914
1902	22,677	4,645	27,322	120,336
1903	22,374	25,713	48,087	171,306
1904	21,913	25,748	47,661	235,704
1905	15,173	32,956	48,129	240,292
1906	25,065	50,267	75,332	368,311
1907			97,776*	480,330
1908	14,446	37,703	52,167	263,968
1909	22,227	106,847	129,101	679,447
1910	33,096	115,836	148,932	716,258
1911	30,170	125,448	155,618	750,649

* Production of Tennessee included.

² From Geological Survey of Georgia, Bulletin No. 11.

Mining of bauxite

As a rule it is very easy to mine because of its comparative softness beneath the surface, it being soft enough in most cases to be dug up with a pick, although black powder is sometimes used to loosen it from its position. The bauxite is usually removed in steps or benches, and loaded into small mine cars. The ore contains a large percentage of uncombined water, which, unless expelled or driven off before shipment, makes it an important factor in the freight cost. The ore after being crushed is passed through long rotary kiln driers, similar to rotary cement kilns.

Three grades of ore are mined, first, that used in the manufacture of metallic aluminum; second, that used in the manufacture of alundum, and third, that used in the manufacture of aluminum salts.

On account of the strict specifications drawn for sulphate of alumina, by those in charge of water purification plants and paper mills, only the ore containing less than 2 per cent of ferric oxide (Fe_2O_3) is used in making aluminum sulphate. The more ferruginous ore is used in the manufacture of metallic aluminum, and the very purest grade of ore is used for the manufacture of alundum.

The following was taken from Bulletin No. 11, Geological Survey of Georgia:

The possible yield of bauxite is greatly limited by the fact, that nearly all but the first grade material is discarded; thereby necessitating the exclusion of a vast quantity of ore, which should, by proper skill and manipulation, find ready utilization at good prices. This condition was, perhaps, made necessary in the beginning, when markets had to be established, in order that home material might compete with the cheap and less pure foreign bauxites of long standing and reputation. The principle has been so rigidly adhered to, by both operator and consumer, during the period of working in the American fields; that it has resulted in creating a demand for the first grade ore only, with practically no sales for the lower grade bauxite.

The writer believes that it is not necessary to demand bauxite of highest purity for making of aluminum sulphate to be used for water purification purposes, and it seems entirely possible that much of the cheaper grade bauxite could be used to advantage in making alum for water purification purposes.

SPECIFICATION FOR BAUXITE USED AT COLUMBUS

The specifications for bauxite now used at the Columbus plant are as follows:

Bauxite to be crushed and dried to contain not over 3 per cent moisture, the analysis to be:

Al_2O_3 not less than 52 per cent.

Fe_2O_3 not more than 3 per cent.

The contract for furnishing the supply needed for the period ending July 1, 1915, was awarded at \$5.50 per ton, 2240 pounds, f.o.b. Bauxite, Arkansas. The freight rate from Bauxite, Arkansas, to Columbus, Ohio, is \$4.40 per long ton, therefore, a ton of 2000 pounds delivered to Columbus, Ohio, costs \$8.84.

Bauxite contains from 58 to 60 per cent Al_2O_3 , whereas, ordinary filter alum usually contains 17 per cent Al_2O_3 , therefore, one ton of bauxite will make a little more than three tons of alum ($\text{Al}_2(\text{SO}_4)_3 \cdot 14\text{H}_2\text{O}$).

Bulletin No. 11, Geological Survey of Georgia, published in 1904, lists the following companies as either owning or working bauxite deposits in Georgia:

The Republic Mining and Manufacturing Company.

The Georgia Bauxite and Mining Company.

The Dixie Bauxite Company.

The Southern Bauxite Mining and Manufacturing Company.

Dealers known to the writer who are in position to quote prices on bauxite are:

Aluminum Company of America, Pittsburgh, Pa.

Mr. Winthrop C. Neilson, 1111 Harrison Building, Philadelphia, Pa.

National Bauxite Company, Philadelphia, Pa.

Globe Bauxite Company, Joliet, Ill.

HALLOYSITE

Good filter alum may also be made from halloysite. The approximate chemical analysis of which is as follows:

	<i>Per cent</i>
Soluble alumina.....	38
Insoluble (silica, etc.).....	40
Water.....	22

Several manufacturers have attempted to make crystallized alum from halloysite, but have failed, because it has been found almost impossible to filter or separate the insoluble portions of the halloysite from the aluminum sulphate syrup. At the Columbus water purification plant, one tank, equivalent to about 6 tons of alum, has been made and used and the results obtained show that aluminum sulphate can be made from halloysite by the process being used at the Columbus water purification plant. Several carloads of this material have been purchased, and further experiments with the use of halloysite as a base for making alum solution will be made.

The North America Chemical Company, with offices at Urbana, Ohio, have a very large deposit of this ore, estimated to be 15,000,000 tons, located near Rome, Georgia, and they have assured the writer a number of times, that if a market can be created for halloysite, the material can be furnished f.o.b. cars, Rome, Georgia, at approximately \$2 a ton.

SPECIFICATIONS FOR SULPHURIC ACID

Sulphuric acid, to be used for making alum, is contracted for, at the Columbus water purification works, under the following specifications:

The sulphuric acid shall be that known as 66° Baumé contact process acid, and shall contain not less than 92 per cent H_2SO_4 .

The material shall be delivered at a uniform rate of not less than 30 tons per month, or at such increased rate as shall be directed.

The sulphuric acid shall be shipped in acid tank cars, provided with all necessary connections for removing the acid from the car by air pressure. Each tank shipment not to contain more than 30 tons of sulphuric acid.

Each tank car lot as a unit shall be the basis for accounting for determining of the amounts payable to the contractor.

GENERAL DESCRIPTION OF PLANT

The plant comprises: 2 lead lined boiling tanks, 2 alum measuring tanks, 1 acid measuring tank, 1 sludge tank, 1 storage tank for sulphuric acid, 1 crusher for crushing bauxite, 1 pulverizer for pulverizing bauxite, conveying, elevating and transmission machinery, bauxite storage bins and weighing device, piping, valves and fittings.

COST OF OPERATION

The following is an estimate of the cost of producing 1000 tons of 17 per cent R_2O_3 alum solution.

468 tons 66° Baumé sulphuric acid at \$12.50.....	\$5,850.00
265 gross tons bauxite at \$9.90.....	2,623.50
Lubricating oil.....	20.00
Steam.....	100.00
Electric current 10,000 kilowatt hours (2 cents per kw. hr.)	200.00
Repairs to plant.....	500.00
Depreciation.....	600.00
Interest on investment.....	600.00
	\$10,493.50

At the Columbus plant it is hardly fair to make any charge for labor because no additional labor is required to operate the new alum plant, consequently the labor item has been omitted in the above estimate.

When lump alum was being used here it was necessary to unload it from the cars, sack and weigh it, store it in the storage house, elevate it to the third floor of the head house, stack it up there and finally dissolve it in solution tanks as needed. In addition to all this handling there were three times as much material to move and three times as much storage space required, because, as has already been explained, 1 ton of bauxite will make 3 tons of alum. No additional help has been employed since this plant has been installed.

DISCUSSION

MR. J. M. DIVEN: How about other chemicals, iron, or possibly arsenic, in the product?

MR. CHARLES P. HOOVER: Three grades of ore are mined, first, that used in the manufacture of metallic aluminum; second, that used in the manufacture of alundum, and third, that used in the manufacture of aluminum salts. At the present time only ore containing less than 2 per cent of ferric oxide (Fe_2O_3) is used in making aluminum sulphate. The speaker believes, however, that it is not necessary to demand bauxite of highest purity for making aluminum sulphate to be used for water purification purposes. It seems entirely possible that much of the cheaper grade bauxite could be used to ad-

vantage in making alum for water purification purposes. Low grade, cheap sulphuric acid contains rather a high percentage of arsenic, and when such acid is used in the manufacture of sulphate of alumina the product will of course contain arsenic. In order to get arsenic free acid it is necessary to specify contact process acid. Professor Bartow, of the Illinois State Water Survey, read a paper at the New Orleans meeting of the American Chemical Society on the presence of arsenic in filter alum, and in this paper it was stated that the quantity of arsenic present in commercial alum was so small that even if water were treated with 6 grains per gallon of highest arsenic content alum which could be found on the market it would be necessary to drink 5000 gallons of such treated water to get a medicinal dose.

PROF. J. M. CAIRD: What is the price of sulphuric acid?

MR. CHARLES P. HOOVER: At the present time we are paying \$12 per ton for sulphuric acid of 66° acid. We have a contract for a year at that price.

MR. A. W. HAWKES: The market price of sulphuric acid at the present time as compared with the price ruling at the time Mr. Hoover made his contract for sulphuric acid has practically doubled, due to the heavy demand brought about by war conditions. It might be very difficult for a water company that has not previously purchased sulphuric acid to secure any at this time at a usable price. Pyrites ore, which comes in material quantities from Spain, is used largely in this country in the production of sulphuric acid and the ocean freights have more than doubled since the outbreak of the war.

MR. CHARLES P. HOOVER: Filter alum, made by the old process, or made and used by the process just described, is made from sulphuric acid, and therefore, it naturally follows that if the price of sulphuric acid increases the selling price of alum will be increased. Even though the cost of acid does increase or double there still remains the same saving in the production of alum by this process over the production by the old process.

A MEMBER: Has the halloysite making of alum not proved successful?

MR. CHARLES P. HOOVER: Attempts to make alum from halloysite, so far as the speaker knows, have proved unsuccessful. A plant for making alum from halloysite was recently built at Urbana, Ohio, but it was only operated for a few months and has now been dismantled. It was found to be practically impossible to filter silica from the crude halloysite syrup. At the Columbus water softening and purification works, where the crude syrup is being used without filtering, concentrating or crystallizing, halloysite is being used successfully.

A MEMBER: You say that the bauxite was mixed in the tank which you illustrated. Do you boil it with a steam coil?

MR. CHARLES P. HOOVER: Briefly the process is as follows: 2 feet of water is first run into the boiling tanks, which are 8 feet in diameter, then the proper quantity of sulphuric acid is introduced. The reaction between the acid and water is so violent as to cause the solution to boil. Bauxite is then dribbled into the boiling acid solution at the rate of about 30 pounds per minute. The reaction between the hot acid solution and the bauxite is violent and the boiling continues as long as the bauxite is being introduced, this usually takes about two hours' time. Live steam is then used to continue the boiling process to complete the reaction between the alumina, of the bauxite, and the sulphuric acid.

PROF. JAMES M. CAIRD: How much of that available alumina is consumed by the sludge? How much of it is lost in the sludge? Did you not say about 40 per cent?

MR. CHARLES P. HOOVER: No; about 6 or 7 per cent of the available alumina is lost.

MR. PHILIP BURGESS: What has been the attitude of the filter alum manufacturers in regard to this process? Have they intimated that in view of the experience at Columbus it might be practical and desirable for them, instead of furnishing the pure crystallized chemical, to contemplate a supply of the materials in the liquid form?

MR. CHARLES P. HOOVER: Will Mr. Hawkes, of the General Chemical Company, kindly answer the question which has just been asked by Mr. Burgess?

MR. A. W. HAWKES: It would not be feasible or practicable for an alum manufacturer to attempt to transport alum solution for the reason that this solution has an acid reaction and attacks most metals, hence it would require a very expensive vessel in which to ship it. Then, too, there would be the question of paying freight from point of shipment to destination on the water in the alum solution.

From the speaker's past experience, he does not believe the manufacturers of alum will make any material advance in the price of sulphate of alumina to their regular customers, no matter where the price of sulphuric acid goes, as it has always been the policy of the manufacturers in the past to take care of their American trade, and contracts are being renewed now from day to day, regardless of the price of sulphuric acid, on the same price basis as ruled before the war. Generally speaking, it is believed the policy of the American alum manufacturer will be to take care of its regular customers in this country on practically the same basis they have been taken care of in the past.

THE EFFECT OF ALGAE ON BICARBONATES IN SHALLOW RESERVOIRS

BY S. T. POWELL¹

The microscopical examinations of public water supplies have become universal, and in many places constitute routine laboratory tests, but these determinations are made principally for the purpose of the treatment of the supplies for the removal of algae and similar micro-organisms causing tastes and odors in the water. Water works superintendents and chemists in charge of such works have given but little study to the biochemical reactions of such plant life when present in reservoirs, and with the exception of various limological investigations that have been made, little data of this character are available. It is a well known fact, however, that these organisms do have a great effect upon the physical, chemical and biological quality of stored water.

In a recent investigation undertaken to determine the effect of dissolved gases in stored water upon ozonization of the supply of the Baltimore County Water and Electric Company, it was clearly demonstrated that certain forms of algae can within a comparatively short time entirely remove the free carbon dioxide from the water, as well as use up a considerable amount of the half bound carbon dioxide, thereby reducing the bicarbonate of calcium and magnesium to normal carbonates of these salts; at the same time causing the dissolved oxygen content of the supply to rise to a point of excessive supersaturation. Such conditions have been noted by many investigators, but these phenomena are not usually to be found in shallow reservoirs where the storage period of the water is relatively short and where the supply of free CO₂ in the raw water is considerable, due to high organic contents.

The two reservoirs used for storage purposes on the Herring Run system of this company are operated continuously, and have a combined storage capacity sufficient for twenty-one days' supply.

¹ Chemist and Bacteriologist of the Baltimore County Water and Electric Company.

The lower reservoir, which was put in use about twenty years ago, is an excavated earthen basin around which a bank was placed. When first put into service the top soil was not stripped but later the greater portion of it was removed to a depth of 12 inches. About four years ago on the bank of the lower side of this reservoir was placed a concrete slab so as to prevent high turbidities in the water on account of washing of the slopes during storms. Due to the organic nature of the contents of the water, there is an abundant food supply for heavy growths of algae, and for this reason it has been necessary to treat the water with copper sulphate many times each summer to keep down the growths.

The second reservoir was built only four years ago and like the first one is an earthen reservoir, but the top soil from this basin was practically entirely removed before it was put into service. This reservoir acts as a preliminary settling basin for the water before it flows to the lower one, the water passing directly from the effluent chamber of this reservoir to the lower one and from there to the ozonization plant.

The raw water feeding these reservoirs is supplied by Herring Run, a small surface water stream subject to some extent to surface pollution of the drainage area, and therefore is usually high in organic matter in suspension and in solution. Algae growths in this stream are as a rule not high but most of the growths develop after the water enters the reservoirs. The raw water receives some aeration just previous to entering the first reservoir, so that the dissolved oxygen is usually about 100 per cent of saturation and the free CO_2 content varies between two and ten parts per million.

In the investigation that was made during the summer of 1914, samples of water were taken regularly as the water flowed into the upper reservoir, again as it flowed into the lower basin, as well as of the effluent from this reservoir and at the pumping station. In all these samples determinations were made of the dissolved oxygen content, free CO_2 , bicarbonate and carbonate alkalinity, as well as microscopical examination of the samples, enumerating the organisms present.

Compilation of these analytical data showed that the water during the passage through the upper reservoir increased in temperature 2.5°F. , while the dissolved oxygen increased from 90 to 99.5 in percentage of saturation. The free carbon dioxide was reduced in all samples and in some of the samples completely exhausted, and

in the samples in which the free CO_2 was all used up the bicarbonates were reduced, on an average, from 52 to 43 parts per million. At the same time it was noted that the average increase in the algae count was from 52 to 260 organisms per cubic centimeter, or an increase of 400 per cent.

In the lower reservoir the average temperature increase over the water in the upper reservoir was 2.5°F. ; the dissolved oxygen increased 25.5 in percentage of saturation, while with one exception the free CO_2 was entirely exhausted, and the bicarbonates were reduced 11 parts per million. The algae count in this reservoir increased 8 per cent over the average count in the upper reservoir water, 444.2 per cent increase over the raw water count.

Diagram I shows that as the algae increased there was a proportional increase in the percentage of saturation of dissolved oxygen, although the temperature of the water was greatly increased at the same time.

As is seen in Diagram II, the free CO_2 was exhausted from the water as the micro-organisms increased and the half bound CO_2 from the bicarbonate was drawn upon to furnish the necessary food supply to support the growth. This chart is interesting as it also shows that exhaustion of the free CO_2 that took place during passage through the reservoir was readily replaced after passing through the aspirators of the ozone plant.

Diagram III shows the number of organisms of each species in relation to the total count.

No tests were made in this investigation to compare the bacterial count in the supply with the multiplication of algae, but in tests made in the laboratory it was found that as the algae increased there was a general tendency of reduction in the number of bacteria in the sample (Diagram IV); also after the algae had been killed by treating the sample with copper sulphate there was a very great increase in the number of bacteria. To what extent the increase in bacteria was due to an increased food supply caused by killing the algae growth, or the other chemical changes in the supply, is difficult to determine, but it is interesting to note, however, that these forms of vegetation can and do cause great chemical and bacteriological changes in a water in which they thrive.

It is not known if all the microscopical forms of life that are found in waters are capable of bringing about these biochemical changes in a water as have been noted in these tests, but the organisms com-



prising the true algae are no doubt more active in this respect. During the process of photosynthesis these organisms store up energy by absorbing carbon dioxide from the water and when this is exhausted draw upon the half bound CO_2 in the form of bicarbonates, giving off oxygen at the same time. It is because of this action that oxygen is formed in the water faster than it can be diffused, causing a condition of supersaturation, as has been noted in these tests.

CONCLUSION

It is seen from the above mentioned tests that certain forms of microscopic life in water can cause rapid changes in the chemical composition of the supply by exhausting the free carbon dioxide and reducing the bicarbonate alkalinity to normal carbonate alkalinity, and at the same time cause the water to become greatly supersaturated with oxygen.

It is quite essential that the growth of algae and allied organisms should be prevented in reservoir water, as the neglect of such conditions may cause serious troubles, not only from complaints due to tastes and odors, but on account of filter troubles so often caused by these organisms. Not only are conditions of this kind prevalent but active growths may so alter the chemical composition of the water as to call for radical changes in the methods of operation of the purification systems.

THE TRUE OBJECT OF WATER ANALYSIS

BY FRANK L. RECTOR, B.S., M.D.

The question of water analysis has been discussed from many angles, by many competent analysts. No uniform agreement has been reached, and doubtless will not be reached as long as waters of variable composition and source are examined.

It has been demonstrated repeatedly that no hard and fast rules can be promulgated for application to all classes of waters. The nearest attempt to this is the standard of impurity established by the United States Public Health Service for drinking water on interstate passenger carriers. To the writer it seems that the relation of the 37° C. count to the permissible gas production is not well balanced. This standard could not be met by many municipalities having what is ordinarily termed a safe supply. Problems entering into the consideration of a municipal supply are so many and varied that one standard for all is out of the question, unless unnecessary requirements are demanded of some.

Waters of surface origin and surface storage will show a different bacterial flora than those of underground source. In surface waters the 37° C. count doubtless suffices for most purposes. But in underground waters from safe sources the 20° C. count gives us much valuable information. In this latter class water organisms growing at 37° C. are, or should be, practically absent, and the 20° C. bacteria are the ones most commonly found.

The 37° C. organisms are looked upon with more distrust than are the 20° C. types; but each group tells its own story of past performances of a water and should be considered. We do not know that all 37° organisms are harmful, in fact we know they are not all harmful; neither do we know that all 20° C. organisms are harmless. Do we know definitely that among the large numbers of bacteria at 20° C. found at times in a water, there are none capable of setting up pathological conditions when taken into the system? Their presence in large numbers tends, at least, to show laxity in the care of that particular water.

As an illustration of the value of the 20° C. count the following results of analysis of filters may be cited. During the past year the writer made a study of the efficiency of filters as installed in homes and offices in Brooklyn. The 550 samples tested were about equally divided between raw and filtered water. The raw water gave a fairly low bacterial count, the average of some 60 analyses giving 28 bacteria at 37° C., and 217 at 20° C. The filter effluents frequently gave low counts at 37° C. but very high counts at 20° C. Had the 37° C. count only been considered, these appliances would have rated as efficient, when as a matter of fact, they were very inefficient, as regards bacterial removal. The following table from the results of the investigation illustrates this point:

RAW WATER		FILTERED WATER	
37°	20°	37°	20°
25	200	0	600
20	100	0	123
11	80	3	325
0	25	0	100
40	100	0	154
11	80	2	79
66	800	21	1,465
443	2400	220	25,000
12	390	7	420
3	80	1	150
6	35	1	230
6	75	0	125
8	50	1	100
27	1600	8	2,500
9	70	0	155

The samples noted above were plated within one hour after collection, and some in much less time, so there was no chance for multiplication between collection and plating.

Each source of water supply should be considered individually, and while general conclusions may be drawn, they must be applied with caution. Analysts should determine what elements in a given water supply, either chemical, bacteriological or microscopical, are subject to the widest variation, and after these facts are established, should devote their routine examination more closely to these vari-

ables. This will show more readily when changes occur and remedies can be applied more quickly.

The above suggestion necessitates frequent and regular examinations of water supplies, a thing which all will agree is highly important. A monthly or quarterly analysis is not sufficient no matter how safe a water is presumably. Analyses should be made weekly, or better daily. The more purification a water undergoes, the more frequently should it be analyzed in order to control the purification.

First hand knowledge regarding a water supply is of the greatest importance. A sanitary survey of the watershed takes equal place with laboratory analysis. The days of "absent treatment" in determining the sanitary condition of a water supply by analyzing a sample submitted with no knowledge of its previous history, are happily past.

In conclusion the writer would emphasize the necessity of a careful study of all influences bearing upon a given water, and a judicious use of that information, rather than judge all waters by a strict laboratory standard.

SOME CONSIDERATIONS IN ESTIMATING THE SANITARY QUALITY OF WATER SUPPLIES

BY W. H. FROST¹

The subject indicated by the title of this paper is obviously too broad to be comprehensively discussed within a brief space. The present discussion will, therefore, be limited, first of all to a consideration of water supplies with reference solely to the causation of typhoid fever, which is the typical, and in this country the most common and serious water-borne infectious disease. The scope may still further be limited to a discussion of the general nature of the evidence upon which an opinion as to the sanitary quality of a water supply must be based.

A scientific basis for estimating the sanitary quality of a water supply with reference to its effect in the causation of typhoid fever can be established only by coördinating the results of two distinct lines of study. The first has to do with the nature and extent of the pollution of the water; the second with the extent of the effect produced by a given amount of pollution in the causation of typhoid fever.

The point which it is desired to especially emphasize is that knowledge of the pollution of a water supply has no significance except as it is coördinated with a knowledge of the effect which the known degree of pollution will produce. However precisely we may be able to determine the nature and extent of pollution, the accuracy of an estimate of the sanitary quality of water must always be limited by the precision with which its effects can be determined or estimated.

DETERMINATION OF THE EXTENT OF POLLUTION

The nature and extent of the pollution of a water supply is determined by studies from two angles, namely: first, by a survey of the sources of pollution, and of the safeguards which stand between

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these sources and the ultimate consumer of the water; second, by laboratory examinations designed to determine the actual amount and kind of pollution present.

SANITARY SURVEY

Since typhoid fever is caused solely by the typhoid bacillus, a sanitary survey of the sources of pollution of a water supply should have reference primarily to the sources of pollution with typhoid bacilli. These organisms, so far as known, breed only in the bodies of infected persons, whence they are discharged in the feces and urine. The term "infected persons" comprises not only all persons known to be ill with typhoid fever, but also a considerable proportion of recent convalescents, and a small proportion, probably about 2 per cent, of all persons who have previously had typhoid fever; perhaps also a small proportion of persons who have never shown recognizable symptoms of infection. By a careful survey it is possible to enumerate all the visible sources of typhoid infection, that is all the known cases of typhoid fever from which a given water supply may become polluted. The concealed sources, that is convalescents and "carriers," cannot be individually located; but their probable numbers in a well studied population can be estimated with reasonable accuracy.

It may be considered that all water, whether taken from surface or underground sources, has at some time since its precipitation been in contact with the surface of the earth, and has consequently been more or less exposed to pollution with the intestinal discharges of all persons and lower animals upon its catchment area. Between the sources of pollution and the ultimate destination of the water are numerous agencies operating to reduce the numbers of typhoid bacilli and other intestinal bacteria which may reach the consumer. These safeguards comprise all the agencies which tend to destroy typhoid bacilli and other intestinal bacteria in the natural and artificial processes of sewage disposal and water purification. In order, then, to arrive at an estimate of the numbers of typhoid bacilli which will reach the consumers of a water supply from known sources of pollution, it would be necessary to calculate accurately the extent of the action of all these agencies which tend to diminish pollution. The problem is so complex as to be impossible of solution without the aid of further means of observation.

BACTERIOLOGICAL EXAMINATIONS

Of the laboratory examinations applicable to determining the nature and extent of pollution of a water supply bacteriological examinations have the most direct bearing upon sanitary quality, which is a question of bacterial pollution. The most specific of the bacteriological examinations in general use are quantitative tests for bacteria of the *B. coli* group, since these tests afford a direct measure of the numbers of intestinal bacteria present, and since typhoid bacilli are found only in association with intestinal discharges. Nevertheless, such tests, however accurate and specific they may be, show only the extent of pollution with intestinal discharges in general; they do not distinguish between pollution with intestinal discharges from lower animals which are not subject to infection with typhoid bacilli, and the much more dangerous pollution from human sources. They still further fail to distinguish between human discharges actually containing typhoid bacilli and discharges free from this specific infection.

CORRELATION OF SANITARY SURVEY AND BACTERIOLOGICAL EXAMINATIONS

The significance of bacteriological examinations may be greatly increased by correlation with a careful sanitary survey, which gives information as to the probable sources of such intestinal bacteria as may be present. It is conceivably possible, by combining a careful sanitary survey with bacteriological examinations, to estimate roughly the probable numbers of typhoid bacilli present in a given water supply. The data necessary for such an estimate are:

1. A knowledge of the numbers of intestinal bacteria present in the water.
2. Such knowledge of the sources of pollution as to enable an estimate of the proportion which intestinal bacteria from human sources are of all intestinal bacteria present.
3. An estimate of the ratio of typhoid bacilli to all bacteria of the *B. coli* group in the discharges of the human population which contributes to the pollution of the given water supply.

A more or less accurate estimate of the probable numbers of typhoid bacilli present in a water supply represents the maximum of information which we may hope to obtain regarding the nature and

extent of the significant pollution. Even this complete knowledge, however, would fail to give an accurate measure of the sanitary quality of the water, unless it could be correlated with a knowledge of the effect which the known numbers of typhoid bacilli will produce in the causation of typhoid fever among persons who drink the water.

To recapitulate; sanitary surveys and bacteriological examinations give only indirect and inferential knowledge as to the probable presence and numbers of typhoid bacilli in a water supply. Even were this knowledge much more direct and exact, it would still fall short of being all that is needed for an estimate of the sanitary quality of the water. The second requisite is an equally exact knowledge of the effects which the known pollution will produce.

DETERMINATION OF THE EFFECTS PRODUCED BY WATER SUPPLIES IN THE CAUSATION OF TYPHOID FEVER

The exact dosage of typhoid bacilli necessary to cause infection is unknown, primarily because it has not been possible to determine directly the numbers of bacilli actually ingested by individuals who have contracted typhoid fever. Determination of the effects of a given dosage of typhoid bacilli even by indirect means is exceedingly difficult because of the probable influence of several variable factors other than dosage in causing infection.

Infection signifies more than the mere introduction into the human body of a given number of living specific organisms; it signifies the establishment of these micro-organisms within the body, their multiplication, invasion of the body tissues and the formation of toxic products, all of which must be accomplished against the resistance of the human body. The introduction of typhoid bacilli into the human digestive tract inaugurates a struggle between the infecting organisms on one side and the human body on the other. Infection results only when the typhoid bacilli have overcome the resistance of the body in the preliminary stages of this struggle, and have reached a stage of development within the body such as to call forth a final effort against them, exhibited in a general reaction which we recognize as the symptoms of typhoid fever.

The following are some of the theoretical considerations which may influence the outcome of the struggle and determine whether

or not infection will result from the introduction of living typhoid bacilli into the human body. On the part of the bacillus there is the factor of "infectivity," or ability to establish itself and multiply within the body. There is also the factor of "pathogenicity" or "virulence," that is ability, after having become established in the body, to give rise to toxic products which will result in illness. It is at least probable that typhoid bacilli may vary widely and perhaps independently in these two respects. On the part of the human body a variable factor is the ability to resist infection, or its antithesis "susceptibility." There is good reason to believe that susceptibility to typhoid infection varies widely in different individuals, and perhaps in the same individual at different times. Except for the fact that resistance is greatly increased by prophylactic vaccination and by a prior attack of typhoid fever, little is known of the circumstances which affect susceptibility; and there are no means of directly measuring the resistance or susceptibility of an individual to this infection.

Other things being equal, we may well suppose that dosage, that is, the number of typhoid bacilli introduced, is the factor which determines whether or not infection will result. It is highly probable that the resistance of the human body against typhoid infection is relative, not absolute; that an individual capable of resisting the invasion of a given number of typhoid bacilli would not be able to resist invasion of say ten times that number. Or, to state it differently, the more numerous the typhoid bacilli introduced, the greater is the probability that some of them will succeed in passing the defenses of the body. In comparing individuals, however, we cannot assume that dosage is the determining factor in infection because of the possible influence of the variable unknown factor of individual susceptibility. If, however, we divide a population into sufficiently large groups, similar in respect to age-distribution and other general characteristics, we may assume that the average of susceptibility is the same in all groups. Given, then, a uniform infective agent, that is typhoid bacilli derived from the same source, we may assume that dosage now becomes the determining factor; and that the occurrence of typhoid fever in any group will be proportionate to the exposure of that group to infection.

Reversing the argument, it may be concluded that the dosage or exposure to infection has been greatest in that group exhibiting the highest proportion of cases. This principle of reasoning is commonly

applied in undertaking to locate the source of typhoid infection. The reasoning is valid only when the population groups are sufficiently large and the number of cases occurring in each sufficient to be significant.

This review of the factors entering into infection is intended to illustrate the difficulties in the way of determining the effects of a given dosage of typhoid bacilli. Even were it possible to undertake human experiments, it is obvious that these would have to be performed on a most extensive scale, with large groups of people and with bacilli derived from many sources, subjected to many conditions. Especially would it be difficult, by such experiments, to arrive at a definite conclusion regarding the minimum dosage of typhoid bacilli which might occasionally result in infection. As a matter of fact, lacking experimental observations, we have only indirect means of determining the probable dosage of typhoid bacilli necessary for infection.

SOURCES OF KNOWLEDGE CONCERNING THE EFFECTS OF WATER SUPPLIES IN CAUSING TYPHOID FEVER

A knowledge of the actual effects of water supplies in the causation of typhoid fever is derived from studies of epidemic outbreaks and endemic prevalence. The endemic typhoid occurring in any community includes the sum total of cases resulting from the operation of all causes. While communities differ markedly in respect to their rates of endemic typhoid prevalence no community of considerable size in this country is altogether free from the disease. An epidemic, in the commonly accepted sense, can not be precisely defined, since the term is a relative one. Any outbreak of cases sufficiently numerous and sudden to stand out distinctly separated from the usual endemic typhoid in that community may be considered an epidemic. The proportion of cases to total population which may be considered to constitute an epidemic depends, then, to some extent, upon the usual rate of typhoid prevalence in the community.

A sharply defined epidemic of typhoid fever affords the best opportunity to determine definitely the effect of a water supply in the causation of this infection. This is so primarily because the very distinctness and sudden development of an epidemic argue the operation of a single, distinct and unusual cause, the spread of infection

from a single source, since it is essentially improbable that two or more unusual sources of infection should have developed independently and simultaneously.

Space does not permit more than the briefest discussion of the methods whereby a water supply may be proven to have caused an epidemic of typhoid fever. Starting with a general knowledge of the sources and potential routes of typhoid infection, and with the assumption that the epidemic has had its origin from a single source, it remains to find the source and vehicle of infection common to all or most of the cases. This is accomplished by investigation of each case, inquiring into all the routes by which infection might have reached this case, that is into the circumstances of any exposure to infection from a recognized prior case of typhoid, and into the sources of all articles of food and drink. Comparing the histories of a sufficient number of cases it is easy to arrive, by elimination, at the vehicle of potential infection common to all, or nearly all. In the case of a water supply used by a large majority of the population the mere fact that all the typhoid patients have drunk this water is obviously of no special significance, since this would necessarily be so, no matter what the cause of the epidemic.

It is, in such case, necessary to *exclude other vehicles of infection*, to show that the water supply is the *only* vehicle of infection common to a significant proportion of the cases. The next step in the evidence is to demonstrate the probability that the water supply was infected with typhoid bacilli at such a time as to account for the epidemic. This can usually be accomplished, even though it may not be possible to find the individual sources from which the water supply became infected. Finally, if it is true that the water supply has been the means of disseminating the epidemic, all the circumstances of the outbreak will be more fully consistent with this than with any other hypothesis, forming a conclusive chain of circumstantial evidence.

A great number of well studied typhoid epidemics, conclusively traced to infection of water supplies, have afforded opportunities to observe and measure definitely the extent of infections caused by these water supplies among their consumers. Unfortunately, the water supplies responsible for such definite epidemics have seldom been closely examined bacteriologically during the period of their known infectivity, so that the extent of pollution which has produced the definitely determined effect is not known. The study of

epidemics has, therefore, failed to give a definite idea of the probable dosage of typhoid bacilli responsible for the causation of known percentages of infection among those exposed.

The effect of water supplies in the causation of endemic typhoid fever is a matter of greater public health importance and at the same time more difficult to determine, because the endemic typhoid in a community represents the sum total of infections from all sources and through all routes. Our most definite knowledge and nearest measure of the effects of known water supplies in contributing to the endemic prevalence of typhoid fever is derived from the study of communities in which a distinctly marked change in the extent of pollution of the water supply has been followed by a correspondingly definite change in the rate of typhoid prevalence. Among the best examples are the many cities in which effective filtration of polluted surface water supplies, previously used without purification, has been followed by a marked decrease in typhoid prevalence. Even here, however, the observed reduction in typhoid prevalence is not an altogether reliable measure of the previous effect of the polluted water supply in the causation of this disease. It is possible, on the one hand, that a reduction in the amount of water-borne typhoid, eliminating a number of local sources of infection, may have resulted in a reduction of cases previously caused by secondary infection from these sources, thus magnifying the apparent effect of the water supply. On the other hand, it may be that the water-borne typhoid, though obviously reduced, has not been completely eliminated. The effect of this would be to reduce the apparent previous effect of the water supply.

A study of such communities as above cited, during the period when known polluted water was used, has revealed certain fairly distinctive characteristics in the distribution of typhoid fever in communities where a large proportion of the total endemic typhoid is water-borne. Briefly these characteristics are:

1. A rate of prevalence notably higher than in other communities, similar in respect to climate and other significant conditions, but using water supplies less highly polluted.
2. A prevalence relatively high during the winter and spring, often reaching its maximum in these months.
3. A relatively uniform distribution throughout the population, without reference to environmental factors other than water supply.

In these same communities, subsequent to purification of their

water supplies, and in other communities where intensive studies have shown that the water supplies are small or negligible factors in the causation of the disease, endemic typhoid shows contrasting characteristics in its distribution, viz:

1. A rate of prevalence generally proportionate to the opportunities afforded for contamination of food supplies with human excrement. Conspicuous factors are faulty methods of local sewage disposal, resulting in the exposure of human discharges to flies and other carriers; and laxity of sanitary administration in respect to isolation of typhoid patients and the safeguarding of milk and other food supplies.

2. A seasonal prevalence quite regularly reaching its maximum during the summer and autumn months, declining markedly during the winter and spring.

3. A relatively high prevalence among those elements of the population who, by reason of their habits or environment, are evidently more exposed to infection from local sources.

These and other more or less distinctive characteristics in the distribution of typhoid fever assist materially in arriving at an estimate of the probable effect of the public water supply in contributing to the endemic prevalence of the disease in a given community. The accuracy of such an estimate is proportionate to the thoroughness and precision of the study upon which it is based. It may be emphasized, however, that the number and complexity of factors entering into the causation of endemic typhoid is such that we can not hope to estimate with quantitative precision the effect of water or any other single factor. An illustration will perhaps serve better than a general discussion to present a conception of the limitations of epidemiologic methods in determining the precise influence of a single factor.

Assume the hypothetical case of a city where a rather highly polluted surface water supply has been in general use, and where the average rate of typhoid incidence is 1000 cases per 100,000 of population yearly. Suppose that, in actual fact, 80 per cent of the total cases are due to infection conveyed by the water supply, the remaining 20 per cent being due to infection from all other sources. The distribution of typhoid in this community would, in all probability, be such as is characteristic of communities in which a polluted surface water supply is the predominant vehicle of infection. By careful study, it should be readily possible to conclude that most of the

typhoid was water-borne, and a relatively small proportion due to infection from other sources. It would not, however, be possible to determine definitely the exact percentage due to water and to other factors respectively. Suppose now that following the installation of filters, providing a water supply showing only slight evidences of pollution, the total incidence of typhoid fever in this community has been reduced to one-fourth, that is 250 cases per 100,000 yearly. Assume that factors other than water cause precisely the same amount of typhoid as previously, that is, 200 cases per 100,000, and that the water supply continues to cause the remainder, or 50 cases per 100,000. The proportion between the water supply and other factors in the causation of the disease has now been reversed, so that the water supply causes only 20 per cent of the total cases. Careful study might now be expected to show conclusively that by far the greater proportion of the cases were due to infection contracted from sources other than water supply. It is, however, extremely doubtful that it would be possible to determine conclusively whether or not the water supply continued to cause a certain small, not definitely determined proportion of cases. In other words, the methods of study are not sufficiently accurate to differentiate between, say, 20 per cent of cases due to water-borne infection, 10 per cent, and none.

The principle which the above illustration is intended to illustrate is simple. A number of factors, more or less obscure, complex and interrelated, enter into the causation of endemic typhoid fever. The operations of individual factors can be distinguished only by circumstantial evidence. Quite evidently the ease and certainty with which the effect of water supply or any other individual factor can be recognized is proportionate to the prominence of the factor. The larger the ratio of its effect to the combined effect of all other factors, the more distinctly can it be discerned. Conversely, as the effect of any single factor becomes smaller in proportion to the total, the greater the difficulty of recognizing and distinguishing it; and there is entirely good reason to believe that the effect becomes indistinguishable before the factor is entirely eliminated. Applying this principle to the judgment of water supplies, the fact that it is impossible to clearly detect evidence of water-borne infection in a community does not satisfactorily prove that the water supply actually plays no part in the causation of this disease. It must then be recognized that we are as yet unable to determine the least amount

of pollution of a water supply which may be responsible for a very slight incidence of typhoid fever.

To recapitulate: bacteriological examinations, combined with a careful survey of the sources of pollution and of the safeguards against them, give accurate knowledge of the extent of pollution of a water supply in terms of intestinal bacteria from all sources. They give only indirect and inferential knowledge of specifically dangerous pollution with typhoid bacilli. To make the knowledge acquired by bacteriological examinations and sanitary surveys significant with respect to the sanitary quality of water, it is necessary to know the *effects* produced by a given amount of pollution. Such effects can be definitely ascertained and measured in the case of epidemic outbreaks, proven to be due to the use of polluted water supplies. The effects can be definitely recognized but not accurately measured in the case of highly polluted water supplies causing high rates of endemic typhoid prevalence. In the case of slightly polluted water supplies it is not philosophically possible to probe by present methods whether or not they may cause a relatively small incidence of typhoid fever, so small as to be obscured by other more prominent factors.

This paper is not intended to present a pessimistic point of view or to deny the possibility of forming a reasonably accurate estimate of the sanitary quality of a water supply. On the contrary, the writer wishes to express his entire confidence in the reliability of an expert opinion, formed after careful study from all angles, and stated conservatively, with an understanding of the limitations of the evidence. Unless these limitations are remembered, however, there is always the danger of drawing too sweeping conclusions from evidence bearing solely upon the extent of pollution of a water supply.

As regards establishing a firmer basis for opinions in the future, this must obviously be accomplished by improving and extending not only laboratory studies of the quality of water supplies, but equally epidemiologic studies of their relation to typhoid prevalence. Methods of epidemiologic study, like bacteriological and chemical methods must be so standardized that results can be summarized into a general fund of knowledge. Routine bacteriological examinations of water supplies, closely coördinated with careful, long-continued epidemiologic studies may be confidently expected to increase, perhaps to an extent not now foreseen, our ultimate knowledge of the sanitary safety of water supplies.

DISCUSSION.

MR. FREDERICK H. STOVER: Dr. Frost made the statement that improved water supplies in many cases got credit for doing more than they really did, in that, while they perhaps reduced the primal causes, and while many secondary contact cases which might have resulted from these did not occur, the water supply erroneously got credit for the whole. Was the statement understood correctly?

DR. W. H. FROST: No; the statement was not quite in that form. The statement was that it was a possibility.

MR. FREDERICK H. STOVER: In that case why should not the water supply have the credit? The decrease in typhoid mentioned above is due to the improved supply, therefore why does not the supply have the credit for accomplishing it?

DR. W. H. FROST: It does get the credit, but there is a possibility of an error.

MR. WILLIAM H. JEWELL: The speaker was very much interested in Dr. Frost's paper, because there are a lot of mighty fine facts stated there—a lot of material to think about and work upon; but the thought was suggested that a matter concerning the vital statistics of typhoid fever in our municipalities was one that was correlated with the milk supply, and the question arose whether we ought not to consider the effects of the water that goes into the milk, either directly or indirectly, in relation to the typhoid statistics of our cities.

An instance occurred at the little village of Park Ridge, near Chicago, where they had twenty cases of typhoid fever, one right after another, in less than ten days, and the public schools had practically to close. Now that was traced by the health commissioner to a certain milk supply. After looking into the question a little bit, it was found that this dairyman was supplied with water from the owner's well. Now, he was within the corporate limits and the supply of the village water works was available. It would seem that it is not doing the water works manager or superintendent justice not to consider those cases, and if possible provide some means to make these dairies take city water when they are within the limits

of main extensions, and the speaker thinks that you will find that where the milk supply of a local community is derived largely from its environments, and water mains are extended out the typhoid becomes less, due to the general propaganda against impure well water.

Dr. Bartow was asked if he knew of any jurisdiction over the water supply of these dairies in the state; and it appears that, in Illinois, there is no investigation being made of the water supplies for dairies, but there should be.

DR. JESSE M. WORTHEN: At Charleston, S. C., last spring we had a hundred and sixty cases of typhoid within three weeks, and it was traced to the milk supply from two dairies, one using cistern water and the other using their own well water. One was within the corporate limits; the other was not, both of them were within three hundred feet of the water supply. The health officer traced the epidemic to these two dairies absolutely; and when they were made to sterilize everything, there were no new cases.

DR. EDWARD BARTOW: Those who have read the report on standards for interstate carriers have noticed that no chemical standards have been formulated, and they will notice that in the work which we did in the examination of our one hundred samples, we made chemical examinations. Apparently the chemical content of the water was pretty good.

MR. CHARLES P. HOOVER: It does not seem advisable, to the speaker, to establish a standard of hardness for water to be used by interstate carriers, but it might be well to insist that water containing more than one grain per gallon excess lime or any excess soda ash should not be used. This would prevent water tanks from being filled with water from railroad water softening plants. The speaker knows from experience that the water at these plants is sometimes grossly overtreated with the softening reagents. Again if the standard demanded a water of low degree hardness it would be a further incentive to use water from these plants. Although we have not, as yet, had time to give the new bacterial standard a thorough test, still we feel that it may be too high.

The daily bacterial records at the Columbus plant indicate that positive presumptive tests in 10 cc. portions of the filtered supply

do not always mean an unsafe water, for they sometimes occur when 1 cc. portions of the same sample do not contain any bacteria. Therefore, the bacteriological standard for water adopted by the Treasury Department for the drinking water supplied to the public by common carriers in interstate commerce may work an injustice upon well regulated municipal water purification plants, for undue suspicion is apt to be thrown upon the plant, and the minds of the citizens may become unduly prejudiced against their public water supply if it becomes known that the water has at some time failed to meet the government requirements.

MR. GEORGE R. TAYLOR: Will Professor Bartow please state whether in his opinion there would be any difference between the storage of a filtered water and the storage of an ordinary spring or raw water in the cooler. That is, will not the filtered water deteriorate more rapidly than water that has not been treated?

DR. EDWARD BARTOW: That would depend upon conditions. With the same kind of bacteria in each sample, the deterioration, which would be measured in the growth of bacteria, would probably be the same. With different bacteria to start with, measuring simply the number of bacteria, there would probably be a difference; but which would deteriorate the more rapidly the speaker would not pretend to say.

DR. JESSE M. WORTHEN: Is the question of whether the ice used in the tanks on the common carriers is artificial or natural ever considered in the quality of the water after it has been iced?

DR. EDWARD BARTOW: Many of the common carriers, especially on the Pullman trains, do not allow the ice to come in contact with the water. In the coaches it is not quite so true. Natural ice is, as a rule, good when taken. It may be, of course, contaminated in handling. That is something that must be looked out for, and the railroads are coöperating to eliminate, as far as possible, any contamination after the water is collected.

DR. JESSE M. WORTHEN: How about the manufactured ice? You very often strike it containing sodium chloride from leaky pans, and sometimes that comes in contact with the water and establishes a

chemical standard of different elements that would increase the chlorine and ammonia if it came in contact with the water.

DR. EDWARD BARTOW: In the samples of water which we analyzed we found some with very little chlorine and a residue of from thirty to fifty parts per million. That would mean that the water which we obtained from the coolers was practically melted ice. It would be possible for a railroad in a country where the residue is high, a complaint that is often made through the southwestern states, to so dilute the water with ice water as to have a pure soft water that will conform to any standard; thus would be avoided any of the physiological actions on the passengers that would be caused by a change from a comparatively soft water to a water with a high residue consisting perhaps of sodium sulphate and magnesium sulphate. In the one hundred waters that we analyzed there were only three that had a residue of over five hundred.

MR. FREDERICK H. STOVER: It would seem that where there is only a bacteriological standard, it might be possible for carriers to get around that easily, simply by filling a supply tank from any convenient source, chlorinating this tank and then filling the containers in the cars from this. In this way it would be comparatively easy to take water from almost any convenient source and yet have it pass inspection when drawn from the coolers in the cars.

While it might be possible to obtain a fairly safe water in this way, and one that would pass the bacteriological test in many cases, the continued use of such a water would be apt to prove undesirable, since the supervision of such a small installation would in a majority of cases be inferior to that of a larger municipal supply.

A chemical standard if adopted should be along broad lines and susceptible of a liberal interpretation.

MR. WILSON F. MONFORT: Will Mr. Hoover explain one matter in his discussion, when he spoke of gas formation; does he refer just to the formation of gas in lactous broth?

MR. CHARLES P. HOOVER: Gas formation in both lactose bile and dextrose broth. In some of the tabulated literature on bacterial work it has been noted, on several occasions, that more B.

coli were found than total numbers of bacteria. If these results are correct then it would appear that too much dependence cannot be placed on results obtained with liquid media.

DR. W. H. FROST: The speaker has no special license to act as spokesman for the public health service, but he may, perhaps, be able to present a point of view from the side of the service. The public health service has not only the authority but the responsibility of protecting the health of passengers in interstate traffic. There are two ways in which the question of controlling the water supplies on common carriers may be approached. First, by instituting an inspection of all the sources of water supply and by maintaining careful supervision over them and over methods of handling, such as to insure that safe water will be served to passengers. This is, perhaps, the ideal way, but a little consideration will show that this method necessitates not only an extensive survey to cover all the sources of supply, but the maintenance of a large force to keep up supervision over these sources and the maintenance of another large force to supervise methods of handling the supplies.

The other angle from which the proposition might be approached is by applying the same principle as is applied in the enforcement of pure food laws; that is, by requiring that the water, as served to passengers, shall conform to certain specified standards of quality, placing upon the carriers the responsibility of choosing such sources of supply and methods of handling as will enable them to meet the requirements. This automatically imposes upon the carriers the necessity of using only good sources of supply and cleanly methods of handling.

The standards adopted by the Treasury Department are quite properly rigid and high, because of the fact which the speaker tried to bring out this morning, that it is difficult to say just where the danger line lies. It seems the only safe policy is to adopt such standards as will certainly insure safe water. Undoubtedly the regulations are rigid; but it is intended that they should be. Common carriers use only comparatively small amounts of drinking water, and, although it may involve using purification processes which would be quite expensive if applied on a large scale to municipal supplies, it is entirely practicable for carriers to purify their water supplies to the point where they meet the requirements.

The speaker does not know exactly what steps the public health

service is taking or proposes to take in enforcing these requirements, or just how it is intended to apply the standards; but does know that the service does not wish to embarrass those of you who have charge of municipal supplies by wholesale condemnation of all water supplies which do not conform to these standards. If the application of these standards will help to encourage municipalities to improve their water supplies, that will be a good thing.

While speaking, in reference to a statement which Mr. Hoover made, that *B. coli*, according to standard methods of testing sometimes turn out ten times as numerous as the total bacteria, the speaker would say that he has never had any such experience; our results are very consistent. Of course it might easily happen that in a single examination or a small series the *B. coli* would figure out more numerous than total bacteria, but the speaker never found it so in the results of any considerable series.

MR. PHILIP BURGESS: Would not the embarrassment be rather upon the common carrier than upon the community? In an instance where a local Pullman sleeper starts in a city where no such certificate has been furnished and the Pullman Company is obliged to ship water at considerable expense into this city from a neighboring community which has a certificate. It seems that the embarrassment is upon the carrier rather than upon the community.

How are these certificates issued, for what period of time, and on what basis of examination?

DR. W. H. FROST: At the present time it is merely a case of certifying water from certain sources. Certificates are issued after examinations made by state or local officials.

MR. PHILIP BURGESS: Not by any national officer?

DR. W. H. FROST: No; the service calls upon state officers to make examinations of water supplies within their own states.

MR. WM. J. ORCHARD: In the New Jersey State Board of Health we had considerable opportunity to see the effect of the certificate issued to railroad companies in regard to the quality of water furnished in cars and stations. Whenever we received a request from any of the many railroads in New Jersey, for certification of a water

supply, we not only examined the records of analyses on file in our laboratory, which we are required by law to make four times a year, but we also, wherever there was any question, had an inspection made of the water shed. The speaker was of the opinion, as other men of that department were, that this matter of certifying the water supply for common carriers would tend very much to improve the character of supplies in small towns where railroads use a considerable quantity of water for their coaches and cars.

MR. GEORGE R. TAYLOR: In regard to certification in Pennsylvania, we have had considerable experience there as a private water company in making out these certificates. Many of the small towns which we supply have no local health authorities that know anything about the purity of the water, but many of these certificates have been turned over to us and signed by us, certifying that we make regular analyses of the water. In cities where we have local boards of health they have filled out these certificates, but our filling out of the certificates has been accepted by the railroad company, at least, as satisfactory. In our section no inspection has ever been made by the state health authorities.

DR. D. P. CURRY: The speaker wishes to ask two questions; they are not altogether related, but will ask both. One relates to submitting samples to the State Board of Health. Now, of course, the government has adopted an arbitrary standard, as they had to do, but the speaker cannot see the reason of the necessity of icing other samples sent to us, for in addition to that we are examining the water supply of the entire state—private wells, cisterns, streams, ponds, any source of water used or consumed by the family. Some portions of our state are seventy-two hours from the laboratory by the methods of transportation. Some are away back in the mountains. The constant complaint, when we send them a container, is "we cannot get ice." It costs too much money, and they say "will you allow us to send them in uniced by parcel post?" If it could be permitted, we could do a great deal more work. Being the only man in Kentucky excepting my assistants doing this work, it is impossible to cover the ground by personal inspection. Our analyst is not busy all the time. We want all the samples of water we can get, and we would like to ask the opinion of the men here who are familiar with the public health association whether it is possible

that samples could be sent to us from a distance, uniced, by parcel post.

We get rather an increase than a decrease of bacteria. Of course, we know that the bacteria die as the result of storage, and it is a question whether, in the course of seventy-two hours, enough of these bacteria would die out to give us a sample which did not show the pollution. We do not object to the increase of evidences in pollution in a private water supply; all we want to know is the potentiality, and it will greatly extend our work and usefulness, and also reach a great many more people in the state of Kentucky, if we can use the parcel post in sending out containers. They are very rigid about using iced samples, but that means that perhaps 30 per cent of the people of the state of Kentucky will be deprived of analyses.

In one place where there were 56 cases of typhoid fever out of 120 or more people, the speaker called to his aid the public health service rather than send uniced samples in; but at the same time did send samples by parcel post to our laboratory, and the results were absolutely identical except, of course, the results in gas. But the speaker wishes that some one here that knows a great deal more than he does about it, would contradict Dr. Frost for him, that the state of Kentucky would be justified in receiving samples for analysis without ice.

There is a condition south of the Ohio river that few men north of it can comprehend. There are whole counties without a privy attached to a school house; counties where not one house in ten has a privy of any sort. When they do have them, the privy and wells are found very close together for the sake of convenience, and it is absolutely vital and necessary to the welfare of the state that we bring to the attention of the people the fact that these wells, which apparently yield clear, sparkling water, are absolutely unfit sources of water for human consumption. If we send them one of our expensive containers made in the form of an ice box, they will keep them for months at a time because they have no ice, and perhaps not one-fifth of the containers are in active use at a time. They will hold them till winter comes and then there is plenty of ice, and possibly by that time conditions in the water have changed. It is really not a small matter with our department and the speaker would like to know if the men here present think that the chances are that the pollution of water would disappear in these conditions?

The other question he wishes to submit is in regard to the advisa-

bility of reclaiming the wash water from a filter plant. One of our water companies wishes to replace the wash water, after sedimentation in a separate tank, into the raw water, and then to get rid of the sludge in the reclamation tank by drainage to low ground. There being no plants of this kind in his state he is without experience in the matter and desires the advice of someone present as to whether to allow it.

DR. EDWARD BARTOW: In a situation such as the gentleman mentions, using some of the containers we would make analyses at the end of six, twelve, twenty-four, thirty-six, forty-eight, or whatever it might be, hours, and determine for ourselves what the results were, and even if we could not conform to the standards, we would make our own standards. We would hesitate, however, to condemn a water which, after storage of four or five days, was shown to contain slight pollution, because of the great possibility of multiplication of bacteria. Care should be taken in the general condemnation of waters of that kind.

With regard to wash water there is a paper submitted by Mr. Babbitt of the University of Illinois (see page 393, vol. 2, JOURNAL AM. W. W. ASSN.), telling about the reclamation of the wash water of the Champaign and Urbana Water Company. That is not exactly parallel to the case which was mentioned. They have been able, however, to save more than 80 per cent of their wash water; allowing it to fall into a sedimentation basin and then pumping the supernatant liquid into the receiving reservoir. By the use of a little alum they are able to remove practically all of the suspended matter, and very little extra burden is placed upon the filters. With a little care, and especially with bacteriological control such an arrangement might be entirely possible in a regular filter.

MR. PAUL HANSEN: The speaker may be able to offer some slight suggestion relative to the difficulties that have been referred to. He happens to have a little familiarity with wells in Kentucky and knows that many of them are badly contaminated.

An analysis of the water is, after all, merely one point of evidence. You may get a good analysis from a well that is subject to contamination at times, so that an analysis may be quite inconclusive. On the other hand, if one knows that a well is near a privy, if one knows that it is subject to the entrance of surface drainage, and if one further

knows that a stable yard and possibly a pig pen are not very far off, there is no need of having an analysis. So that before any analyses are made at all there should be obtained a complete description of the source of supply, using perhaps blank forms for this purpose. If it is found that the source is an ordinary open type well, that it is in close proximity to various sources of contamination, one can say offhand that that well is not satisfactory because it is unquestionably in danger of contamination and that an analysis is not worth while until the sources of danger are removed.

While in Kentucky the speaker pursued that policy, and was much more certain of his judgment of the quality of water from wells than he would have been with analyses alone.

MR. FREDERICK H. STOVER: In reply to second question the speaker wishes to say that in the treatment of clear water he believes it is an advantage to mix the wash water with the water under treatment, because the residual coagulant present in the wash water forms a desirable matrix expediting the formation of a new floc.

MR. WILSON F. MONFORT: Some second hand experience regarding the sending of uniced samples may be of interest. There was a plant in one corner of Missouri sending samples to a state laboratory for examination. The first, the second, the third and the fourth were condemned. The fifth one arrived, was passed upon as good, with the remark, "This is the first sample we have gotten from your city which was iced." All the others had high counts and bad records. It is questionable whether you would not get too bad a result from your uniced samples. If you are limited to sending small packages by parcel post, have you considered putting your portion of media into the sterile bottle and having it incubate on the way for fermentation test only? Is it possible for you to accomplish that and have the incubation under way before the sample reaches you? The speaker is not sure that that could be worked out. You might have trouble; you might have explosions; you might have leakage; but is there not some way of having your package so put up that you might get an enrichment on the way and examine your sample afterward. You might have to use solid media before the method could be gotten into shape. The speaker would be very doubtful about a sample by parcel post which was then submitted to the ordinary examination.

MR. PHILIP BURGESS: The speaker has had some experience similar to those of Mr. Monfort. He was employed by the Ohio State Board of Health for some three years to investigate the water purification plants in Ohio; and, in a number of instances, he made it a special point to send samples into the laboratory and at the same time to make bacterial tests at the plant. The tests showed conclusively that, in the summer time, even when the samples were well iced, results obtained in the laboratory may have little, if any, value, because the total number of bacteria generally increases and because *B. coli* sometimes increase and sometimes disappear altogether.

Where it is not possible to remain on the ground sufficiently long to complete the presumptive *B. coli* tests, experience indicates that satisfactory results may be obtained by inoculating the fermentation tubes and shipping the tubes by express to the laboratory, where they are incubated. Apparently similar results are obtained by this method as would be obtained if the incubation commenced when the tubes were first inoculated. Moreover, such a procedure, of course, saves considerable time in the field.

The application of hypochlorite of lime to a water supply also introduces a feature which affects the results of analysis which may be obtained on the ground or on shipped samples. The germicidal action of the hypochlorite of lime continues, and, of course, affects the shipped samples, so that a less bacterial content may be obtained when samples are shipped to and analyzed at the laboratory than would be obtained were the samples plated and incubated immediately after collection. This feature, of course, has an important effect upon the value of analyses obtained from shipped samples.

MR. WM. J. ORCHARD: It might be of interest to the gentlemen present to know that about two months ago in New Jersey, at the suggestion of Dr. Fitz Randolph, in charge of the laboratory of hygiene, there was instituted a system of shipping 250 centimeter bottles out to the various water companies, the supplies of which were obtained from deep wells and the quality of which had been ascertained pretty definitely by quarterly analyses for several years previous. These samples would be sent back to the laboratory at Trenton by parcel post. That was largely brought about in order to economize in the collection of samples, which the law required must be collected by the inspectors of the state boards of health.

The speaker is unable to report the results of this procedure, but in discussing it we decided that in the case of deep well waters, in the twenty-four to thirty-six hours that it would take for the samples to reach the laboratory, the bacteriological changes, if any, would not be of sufficient consequence to influence the interpretation of the analysis, in so far as we knew the quality of the water from several years previous work.

In regard to the other matter that the last gentleman mentioned, it was our practice in New Jersey to inoculate bile tubes in the field when we were testing water supplies, and then ship them to the laboratory or carry them there in order to save time in incubation and in order to get our results sooner than we would had we waited to reach the laboratory before inoculating.

MR. W. W. DE BERARD: Is there not on the market at the present time a sample bottle in which the thermos bottle principle is used? If such a bottle were filled and held for a few hours in the water of which you want a sample, so as to obtain the same temperature, the sample would probably retain that temperature for two or three days without material change.

MR. PAUL HANSEN: The thermos bottle referred to by Mr. De Berard is in the office of Mr. Robert Weston, of Boston.

MR. WILSON F. MONFORT: The one referred to as coming from Kansas is gotten up by Mr. Young and two or three others at Independence, but that, however, requires ice. It is simply a fireless cooker proposition that carries four or more ordinary sized bottles. The one that Mr. Weston uses is a stock thermos bottle, and carries from three to eight two-ounce glass stoppered bottles. The quart size is not large enough to take a number of four-ounce bottles, but would take a single unit for each sample if you are sending the ordinary four-ounce bottles.

HOW TO DETERMINE THE SIZE OF TAP AND METER

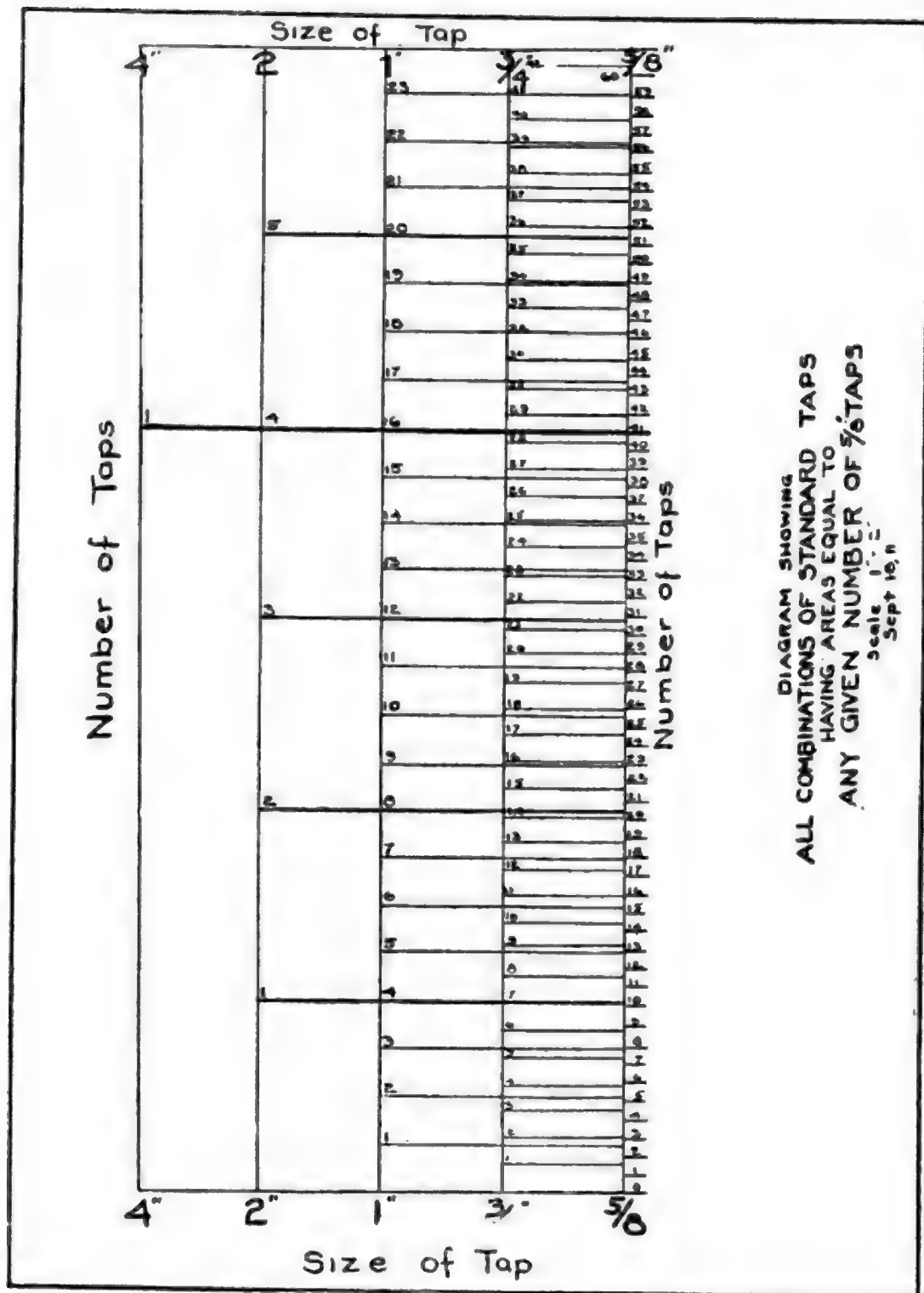
BY JACOB KLEIN

Up to recently a rule was in force permitting only one $\frac{5}{8}$ -inch tap for each 25 foot frontage, no matter whether the building was two stories or twelve stories high. There was no way out of it for the consumer except to agree to install meters for the entire supply, when an additional tap or a larger tap in the place of the one in use would be granted.

Careful studies have been made to arrive at a fair basis of determining the size of tap for all classes of buildings, and it was found that the only fair and equitable basis was the "floor area basis," and early last year a rule was adopted by the water department which permits the use of a $\frac{5}{8}$ -inch tap for the first 7500 square feet of floor area, a $\frac{3}{4}$ -inch tap for the first 15,000 square feet and above 15,000 square feet one $\frac{5}{8}$ -inch tap for every 10,000 square feet of floor space, computed as follows:

Up to 7,500 square feet.....	One $\frac{1}{2}$ -inch tap
7,500 to 15,000 square feet.....	One $\frac{3}{4}$ -inch tap
15,000 to 20,000 square feet.....	Two $\frac{1}{2}$ -inch taps
20,000 to 30,000 square feet.....	Three $\frac{1}{2}$ -inch taps or equivalent
30,000 to 40,000 square feet.....	Four $\frac{1}{2}$ -inch taps or equivalent
40,000 to 50,000 square feet.....	Equivalent of five $\frac{1}{2}$ -inch taps.

The floor space is computed by multiplying the area which the building occupies by the number of floors, exclusive of the cellar. The area of the building is computed from the general overall dimensions exclusive of small projections, such as bay windows, porches, etc. An extension to be included in the floor space must be at least 150 square feet per floor. The resulting figures are called the next higher even thousand; viz., 217,500 is considered as 218,000 square feet. No building is granted more than four taps, except upon written application accompanied by plans and specifications upon which is shown and described specifically the nature or class of business to be conducted and the purpose for which the water is required. The total number computed is reduced to equivalents. Buildings hav-



ing floor space of less than 7500 square feet are granted an additional $\frac{5}{8}$ -inch tap, provided it is found that the pressure under which the water is delivered through the main which supplies the building is not sufficient to raise water throughout the building without the aid of a pump.

It is sometimes found necessary to give applications for taps to supply breweries, ice houses, laundries, power plants, etc., special consideration as the floor area rule cannot always be applied to them. The contractor or plumber is required to file plans and specifications, showing the nature of business to be conducted and the purpose for which the water is required; also the quantity of water required per hour. These are investigated and a report stating the reasons for granting a larger size tap is filed simultaneously with the issuance of the permit.

The size of tap for fire purposes is determined by the capacity of the fire pump, or by the number of sprinkler outlets.

The standard sizes of taps in use are $\frac{5}{8}$, $\frac{3}{4}$, 1 and 2-inch. In Brooklyn $1\frac{1}{2}$ -inch taps are also used. The standard sizes for connections or "wet connections" are 2, 4, 6 and 8-inch. The sizes of meters are $\frac{5}{8}$, $\frac{3}{4}$, 1, $1\frac{1}{4}$, $1\frac{1}{2}$, 2, 3, 4, 6-inch, etc.

A 1-inch is the largest screw tap allowed on mains 8 inches in diameter or less. A 2-inch screw tap is made on mains 10 inches in diameter or over. Taps larger than 2 inches are wet connections.

Although there is no rule which makes it compulsory for owners of premises which face two streets to have a supply from each street the consumers are advised to do this, so that the least amount of inconvenience is experienced when it becomes necessary to shut down a main in one street. It is required, however, that in such cases a check valve be placed on each service pipe to prevent back pressure.

The size of the meter is determined by the size of the tap. A meter of the same dimensions as the tap, or *one* size larger only is permitted, but in no case may the meter be of smaller size than the tap. The rule limiting the meter to *one* size larger than the tap or connection is on account of the fact that a large meter when supplied through a small tap will not register correctly. Consumers in nearly all cases avail themselves of the privilege of using a meter one size larger than the tap.

DISCUSSION

MR. WILLIAM LUSCOMBE: It would seem that, while that might be a good way of determining the size of the taps, yet there is another very important factor that should be considered, namely, the number of fixtures, the kind of fixtures and for what purpose the water is to be used. We all know of buildings that have large floor space where little or no water is used; and on the other hand, buildings of very limited floor area where the registration of meters applied to the service is comparatively great. The fixtures, faucets, valves, etc., and the purpose or purposes for which the water is to be used should also be considered as governing factors, as well as the floor space.

FRANCHISES OF PUBLIC UTILITIES AS THEY WERE AND AS THEY ARE

BY HENRY C. HODGKINS

The developing and perfecting of what the real estate man calls modern conveniences and of those structures necessary for furnishing the means for the employment of these conveniences, which the publicist calls public utilities, have been so rapid and have become so necessary to every human habitation that public utilities and their franchises are receiving the widest publicity and attention as a great economic question. It is the purpose of this paper to consider only such utilities as are ordinarily within the limits of the municipality.

Mr. D. F. Wilcox makes the following list of municipal utilities: electric light and power, telephone, telegraph, electrical signals, electrical conduits, water supply, sewerage, central heating, refrigeration, pneumatic tubes, oil pipe lines, and artificial and natural gas. To these the statutes of some of the states have added street railroads, storage and wharfage.

We can better appreciate the relation of these utilities to the public and the engineer by knowing something of their history.

PNEUMATIC TUBES

Mail was transmitted about $\frac{1}{2}$ mile through a pneumatic tube as an experiment in the years 1893-1898. In 1908 there were 42.2 miles, all operated by private companies under contracts with the government.

CENTRAL HEATING

Central heating is said to have been in successful operation since 1877. In 1902 there were 130 plants, of which 82 were operated in connection with other utilities.

SEWERS

Time will not permit to enter upon this subject, but the author will merely state in passing that the municipal year book of 1902

gave 47 cities and towns as having sewerage systems operated by private companies under franchises.

TELEGRAPH

The telegraph was invented about the middle of the nineteenth century. The Western Union Telegraph Company was incorporated in 1851, under the name of the New York and Mississippi Valley Printing and Telegraph Company, and assumed its present name in 1856.

SIGNALING SYSTEM

Signaling systems were developed with the telegraph. A great variety of wire signaling systems have been evolved. The wireless systems have hardly reached the classification of municipal utilities.

TELEPHONE

The first regularly equipped commercial exchange was in New Haven in 1878. From then until 1894, the date of the expiration of the patents, the business of the country was controlled by the Bell Telephone Company.

ELECTRIC STREET RAILWAYS

Electric trolley roads were first put into operation about 1888. The first one was in Iowa, at Des Moines, the second one, at Richmond, Virginia, was completed in 1888. There were others following closely. The writer's diary for 1888 states that in June, on a trip to see President Wilber of the Lehigh Valley Railroad in regard to a steam road, he stopped at Scranton to see an electric trolley in operation. They had only a few cars. There were also cars in operation in Wilkesbarre and they had difficulty with the trolley, and at corners a man would climb to the top of the car to keep the trolley in contact with the wire.

ELECTRIC LIGHT

The first central station operating electric arc lamps was installed in San Francisco in 1879, the Erush system. The Edison system of incandescent lighting was first put into operation in connection with central station lighting in 1880. It was not until some years later that the alternating current became a commercial possibility. In

1888, the writer installed a central station alternating machine at Rochester, Minnesota. At that time the Thompson and Houston Company, the predecessor of the General Electric, would give no guarantee whatever for their alternating dynamo, not even that it would generate the current.

In 1902 there were 3620 central electric lighting stations; in 1907 there were 4714 central electric lighting stations; in 1902 there were 815 or 22½ per cent owned by cities. About 1907 the hydro-electric commission of Ontario was in operation and had contracted for 100,000 h. p. at Niagara Falls and Toronto had contracted for 15,000 h. p. at \$14.75 to \$17.75.

GAS

Richmond, Virginia, may claim to be the first city in America to be lit with gas. "As early as 1800 a tower some 40 feet high was erected and the numerous jets that surmounted it were lit from gas generated below, by a process invented by a man named Henfry. It proved of no value."

Gas is said to have been used for lighting in Manchester, England, about 1804-1805. In 1813 it was used for lighting London Bridge. In the United States a man in Newport, Rhode Island, lighted his premises with gas in 1806. A gas company was organized in Baltimore in 1816. Boston and New York 1822-1823, Brooklyn and Bristol, 1825, New Orleans 1835.

The early history, so far as available, was a series of failures. The first public gas light in Boston was in 1829. Gas sold at \$5 to \$6 per 1000 cubic feet. In 1850, according to the federal census, there were 30 gas plants. The writer for a time owned a plant that was built in 1851. In 1900 there were 877 gas works.

WATER WORKS

Water works are the oldest of all municipal utilities. Water by some means has always been supplied, but it is only since about 1800 that it has been supplied in this country through regular systems of piping.

According to the *Manual of American Water Works of 1890-1891*, there were in the United States in 1800, sixteen water works of which one was owned by the public and fifteen by companies.

The increase for the next fifty years was slow.

In 1850 there were 33 public and 50 private; in 1875 there were 227 public and 195 private; in 1880 there were 293 public and 305 private; in 1890 there were 878 public and 1159 private; in 1897 there were 1690 public and 1489 private.

In Canada in 1890 there were 59 public and 36 private; in Canada in 1897 there were 109 public and 35 private.

There has been no compilation of water works statistics since 1897. The number of works has greatly increased, and the ratio of public to private works has also greatly increased, both from new construction and purchases by cities of private works.

It is therefore apparent that private capital has taken the initiative in all the municipal utilities, and, with the exception of water works, still remains in the possession and operation of a large proportion of the municipal utilities. Probably more than 90 per cent of all municipal utilities, outside of water works, are operated by companies. In this connection the writer would call your attention to the statement that prior to 1880 there were probably not to exceed 700 of what we call municipal utilities in existence in this country, and in 1850 only about 120. The question of rights under which these companies operated was not regarded of great importance prior to 1880.

The inventions of recent years, and the demand for all sorts of conveniences, have so increased the utilities that it is essential to the engineer to understand the franchises under which they operate.

Finch gives the following definition: "A franchise is a royal privilege in the hands of a subject." This definition was accepted by Blackstone and others. Another definition by Kent is that franchises are certain privileges conferred by a grant from the government and vested in individuals.

A definition generally accredited to Chief Justice Taney of the United States supreme court is, "Franchises are special privileges conferred by the government on individuals and which do not belong to the citizens generally of common right."

The word franchise is frequently used to denote a right or privilege, in a legal sense franchise and liberty are said to be synonymous.

The definition by Finch has been criticised as not being strictly correct under our government and laws, since franchises are based in this country upon contracts between the sovereign power and private citizens made upon a valuable consideration for purpose of public benefit as well as individual advantage, and it is said by Chancellor

Kent, "Franchises contain an implied contract on the part of the government not to invade the rights vested, and on the part of the grantees to execute the conditions and duties prescribed in the grant."

Distinction should be made between corporate franchises and special franchises. A corporate franchise is the right to exist as a corporation and do the business specified. A special franchise is, for example, the right to enter upon highways, public grounds, etc., and place certain structures thereon.

Much confusion has existed as between a contract and a franchise for the reason that both are frequently embodied in the same ordinance. As stated by Chancellor Kent, a franchise generally contains an implied contract or covenant, but a contract to render a specific service as, for example, lighting of streets or water for fire protection is not a franchise, although a franchise may be and generally is necessary for carrying out the contract.

For the purpose of comparison and also to show what the general provision of statutes has been regarding franchises the following table was compiled from information obtained from the two volumes of *The Law of Incorporated Companies Operating Under Municipal Franchises*, by Allen R. Foote, and Charles E. Everett, which brings the subject down to 1892.

In 41 states in the table, the length of time for which a franchise may be granted according to the general law is unlimited in 16 states; in 18 states franchises may be perpetual. In 5 states franchises are granted by special charters and no limit is mentioned. In 27 states the length of time for which a contract could be made is not limited by the general law.

In Nebraska a contract must provide for purchase after ten years. In Wyoming a franchise must contain the express condition that the municipality shall have the privilege of purchasing after twenty years.

Pennsylvania and Ontario are the only instances where the terms of purchase are explicitly stated and they are so widely divergent that the writer will give each of them. In Pennsylvania "A municipality may, after twenty years, become the owner of a gas or water company on paying therefor the net cost of erecting and maintaining the same, with interest thereon at the rate of 10 per cent per annum, deducting from said interest all dividends theretofore declared."

STATE	LENGTH OF FRANCHISE	PERPETUAL	LENGTH OF CONTRACT	REMARKS
Alabama.....	No general law. Usually 25 years.	Not perpetual.	As agreed.	
Arkansas.....	No general law.	Not perpetual.	As agreed.	
California.....	Not to exceed 25 years.	Not perpetual.	As agreed.	
Colorado.....	20 years Denver. 25 yrs. for water and gas. Gas other places. Special charters. Special charters.	Not perpetual.	1 year.	
Connecticut.....				
Delaware.....				
Florida.....	Special charters	May be perpetual.	No limitation.	Unless specified in city charter.
Georgia.....	Usually granted for definite time.	May be perpetual.	No limitation.	Legislature has limited corporate exemption to 20 years.
Idaho.....	50 years.		50 years.	
Illinois.....	Street railways 20 years. Others no limit.	May be perpetual.	No limitation.	Limited as to city debt.
Indiana.....	No limitation.	May be perpetual.	No limitation.	Limited as to city debt.
Iowa.....	25 years,		Implied 25 years.	
Kansas.....	20 years.		Implied 20 years.	
Kentucky.....	20 years.		Implied 20 years.	
Louisiana.....	99 years.		No limitation.	
Maine.....	As granted.	May be perpetual.	No limitation.	
Maryland.....	No limitation.	May be perpetual.	No limitation.	
Massachusetts....	No limitation.	May be perpetual.	No limitation.	Law seems to provide for free water for fire purposes.

Michigan.....	No limitation or for 30 years.	May be perpetual.	30 years.	No special provision for contract. If ratified by vote.
Minnesota.....	50 years.	Not perpetual.	No limitation.	
Mississippi.....	99 years.	Not perpetual.	25 years.	
Missouri.....	As granted.	As granted.	20 years.	
Nebraska.....	First class 20 years. Second class cities water 25 years, gas 21 years.		Implied 25 years.	If ratified by vote, and reserves right to purchase after 10 years.
Nevada.....	No limitation.	May be perpetual.	As agreed.	Franchise granted for all sorts of purposes. City contract not required.
New York.....	Gas and electricity 50 years; may be renewed	May be perpetual.	5 years.	Contract not to exceed 2½ mills on \$1 of taxable property and may be for not exceeding 30 years if ratified by vote.
New Hampshire...	No limitation.	May be perpetual.	No limitation.	
New Jersey.....	No limitation.	May be perpetual.	No limitation.	
North Carolina...	60 years.		No limitation.	
Ohio.....	Street railways 25 to 50 years.	May be perpetual.	10 years.	Contract for water may be for 20 years if ratified by vote.
Pennsylvania.....	No limitation.	May be perpetual.	10 years.	
Oregon.....	No limitation.	May be perpetual.	No limitation.	
Rhode Island.....	25 years.		No limitation.	
South Carolina...	No limitation.		No limitation.	
South Dakota.....	Street railways 20 years. Others no limitation.	May be perpetual.	No limitation.	

STATE	LENGTH OF FRANCHISE	PERPETUAL	LENGTH OF CONTRACT	REMARKS
Tennessee.....	Perpetual; subject to repeal.		No limitation.	Constitution prohibits perpetuities.
Texas.....	50 years.		No limitation.	
Vermont.....	No limitation.		No limitation.	Gas companies are authorized to do electric lighting.
Virginia.....	No limitation.		No limitation.	
West Virginia.....	No limitation.	May be perpetual.	No limitation.	
Wisconsin.....	Gas 50 years. Others no limitation.	May be perpetual.	No limitation.	Contract with gas company 10 years.
Wyoming.....	Street railways 10 years. Water 20 years.		10 years for water.	Franchise for water must be ratified by vote and must contain right to purchase within 20 years.
Ontario.....	50 years.	50 years.		
Quebec.....	50 years.	50 years.	10 years.	

In Ontario: "The arbitrators in determining the amount to be paid for such works, gas or water, and property, shall first determine the actual value thereof, having a regard to what the same would cost if such works should be then constructed, or such property then bought, making due allowance for deterioration, wear and tear and making all other proper allowances, and shall increase the amount so ascertained by 10 per cent thereof which increased sum the said arbitrators shall award as the amount to be paid by the corporation to said company, with interest from date of their award."

EXCLUSIVE FRANCHISE

Many companies held that their franchises were exclusive. The New York state court of appeals, in the case of the Syracuse Water Company vs. the City of Syracuse,¹ decided, "A franchise to be exclusive must therefore be given by the terms of the grant, otherwise it is not a resultance from its nature." This case was carried to the supreme court of the United States and by that court was dismissed.

Therefore there are probably very few, if any, exclusive franchises, but there are probably a good many perpetual franchises.

The length of contracts for public services has been fixed by the local authorities even where the statutes placed no limitations. Some were made for only one year at a time, a great many were made for twenty years and a smaller number for twenty-five or thirty years.

The history of American water works is the most fruitful field for the study of franchises, owing to the fact that such a large number of works have been constructed under franchises, and, after being operated during the term of the franchise or of a long contract, have passed to the possession of the municipality, and in some instances have been forced out of existence by the competition of additional works built by the municipality. In granting these franchises it was the custom in many cases for the city to employ an engineer to lay out the system of pipe distribution, specify the reservoir or standpipe and the pumping machinery, and prepare the franchise, and then call for bids on a hydrant rental basis. In some cases complete detailed specifications were embodied in the contract. The usual custom was to provide a test of fire streams which really measured the capacity of the works. In the writer's experi-

¹ 116 New York, page 167, October, 1889.

ence these tests ranged from 4 streams 80 feet high in some small places to 30 streams 100 feet high, as at Peoria, Illinois. Complete schedules of rates to private consumers were as a rule embodied in these franchises, and as a general rule the right or option to purchase was reserved to the municipality.

During the ten years from 1880 to 1890, over 850 works were built under franchises, and, as the hydrant rental contracts were mostly for twenty years or under, these contracts have expired, and in a large number of cases the works have passed to the ownership of the municipalities.

Of the over 60 places of the writer's experience nearly 90 per cent have passed to the ownership of the municipalities.

Of the 12 places in Canada only one remains in the hands of a company.

Of the 10 electric plants, 7 are still owned by companies.

It is well to stop and consider the element of time in these matters. A majority of these utilities have been evolved and made practicable within the life-time of most of us, and it is less than the span of a generation since the terms of municipal franchises were charged with being in conflict with the interests of the public. In fact it was not so much franchise seekers as it was a seeking after those who would accept of franchises. As has been shown, time limit was lightly considered, and the limitations that were made were due more to a confusion of terms than to intent to cause the demise at specified date. As time passed and the business of franchise companies developed to a profitable basis, a change in sentiment was brought about. A fierce strife between the municipality and the utility corporation occurred in many instances; a clamor for shorter contracts and a definite term for franchises, fixing a date when the utility must cease to exist and its funeral obsequies be celebrated. The fallacy of such reasoning was soon evident. For the state to kill its own creation at a fixed date only to replace it by a similar creation which might, perchance, pass to the same hands as the owners of the late deceased was absurd. Moreover utilities must not cease to exist. To shut off the city's light would be a calamity; to deprive it of water would mean famine; to stop the flow of gas means freezing, and to interrupt the telephone service would be an intolerable inconvenience. Utilities are absolutely essential. They must be maintained and operated in the most certain and efficient manner, and must continue indefinitely, or until something better

has developed that can take their place. In plain language, a utility can not be divested of its franchise and the only way a franchise can in equity terminate is by the property going to the source from which the franchise emanated.

The writer has due regard for the many able minds that believe that the term of a franchise should be short and definite. Their position is, however, entirely untenable unless they provide for the orphaned property after its right to live and be utilized has terminated.

All these considerations are bringing about a change in the manner in which public utilities are regarded. Public service commissions are becoming the rule.

The railroad commission of Wisconsin was established in 1905 and two years later was given jurisdiction over all public utilities. The law in the state of New York establishing two public service commissions was enacted in 1907, during the administration of Governor Hughes. This law as amended in 1910 is used as an argument in many of the states for similar laws. The rapid spread of commission legislation; the vast number of decisions of different commissions reasoning from different viewpoints; the very considerable contribution by engineers on the terms of regulation, valuation and rates has created a mass of literature scattered through pamphlets, society reports, etc. This mass of material has yet to be compiled and made available for the guidance of the interests affected.

In 1913 The National Civic Federation published a work entitled *Commission Regulation of Public Utilities*. "A compilation and analysis of the laws of 43 states and of the federal government for the regulation by central commissions of railroads and other public utilities." From this work and an article in the *Annal* by I. L. Sharfman, much of the following information was obtained.

Since 1913 two states have established commissions and seven others have added largely to their statutes. Delaware, Utah and Wyoming² are the only states having no central commissions. New York, Massachusetts and South Carolina have each two commissions and in Massachusetts the telephone and telegraph are under the jurisdiction of the highway commission.

The following table shows the utilities of each state which are under the jurisdiction of their respective commissions.

² Law providing for commission passed in 1915.

	COMMON CARRIERS	STREET RAILROADS	TELEPHONE	TELEGRAPH	GAS	NATURAL GAS	ELECTRIC LIGHT	WATER	POWER	HEATING	IRRIGATION	PIPE LINES	STORAGE	WHARFAGE	TRANSMISSION
Alabama.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Arizona.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Arkansas.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
California.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Colorado.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Delaware.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
No commission	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Connecticut.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Florida.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Georgia.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Idaho.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Illinois.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Indiana.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Iowa.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Kansas.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Kentucky.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Louisiana.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Maine.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Maryland.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Massachusetts.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Gas and Electric.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Railroad Commission.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Highway Commission.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Board of Health.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Minnesota.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mississippi.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Missouri.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Montana.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Nebraska.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Michigan.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Nevada.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
New Hampshire.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
New Jersey.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
New Mexico.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
New York.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
North Carolina.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
North Dakota.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ohio.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Oklahoma.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Oregon.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pennsylvania.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Rhode Island.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

	COMMON CARRIERS	STREET RAILROADS	TELEPHONE	TELEGRAPH	GAS	NATURAL GAS	ELECTRIC LIGHT	WATER	POWER	HEATING	IRRIGATION	PIPE LINES	STORAGE	WHARFAGE	TRANSMISSION
South Carolina															
Railroad Commission	—	○	—	—											
Public Service Commission.....									○	○	○	○	○	○	†○
South Dakota..	—	—	—	○	○	○	○	○	○	○	○	○	○	○	○
Tennessee...	—	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Texas...	—														‡
Utah															
No commission															
Vermont.....	—	—	—	—	—	○	—	○	—	—	○	—	○	○	○
Virginia.....	—	—	○	○	—	○	—	—	—	—	○	—	○	○	—
Washington.....	—	—	—	—	—	—	—	—	○	○	○	—	○	—	—
West Virginia.....	—	—	—	—	—	—	—	—	—	—	○	—	—	—	—
Wisconsin.....	—	—	—	—	—	—	—	—	—	—	○	—	—	—	—
Wyoming															
No commission. Law passed at 1915 session of legislature															

* New law goes into effect September 1, 1915.

○ indicates no control.

— indicates control by commission.

† Does not apply to Charleston, Marion, Spartanburg, Sumter, Union or town of Conway.

‡ New law being prepared during winter of 1915. (Law passed and took effect 90 days after adjournment of Legislature.—Editor.)

Twenty-four states make express provisions for the valuation of properties of public utilities by the commissions.

Arizona	Maryland	Oklahoma
Arkansas	Massachusetts	Oregon
California	Michigan	Pennsylvania
Florida	Minnesota	South Dakota
Georgia	Mississippi	Texas
Illinois	Nebraska	Washington
Indiana	New Jersey	West Virginia
Kansas	Ohio	Wisconsin

Rates must be just and reasonable. A reasonable average return upon the value of the property actually used in the public service

and the necessity of making reservation out of income for surplus and contingencies are generally recognized. Unjust discrimination is almost invariably prohibited. Publicity in the establishment and change of rates is as a rule required.

Authority to fix, establish or prescribe rates and charges is given in 24 states.

Arkansas	Montana	Charleston, Ma-
Florida	Nebraska	rion, Spartanburg,
Georgia	Nevada	Sumter and Union
Illinois	New Mexico	or the Town of Con-
Iowa	New York	way)
Kansas	North Carolina	South Dakota
Louisiana	North Dakota	Tennessee
Michigan	Oklahoma	Texas
Mississippi	South Carolina	Virginia
Missouri	(does not apply to	Wisconsin

Authority to regulate accounts, etc., is given in 27 states.

Alabama	Massachusetts	Oregon
Arizona	Michigan	South Dakota
California	Minnesota	Texas
Connecticut	Nebraska	Vermont
Florida	Nevada	Washington
Georgia	New Hampshire	Wisconsin
Iowa	New Jersey	Indiana
Kansas	New York	West Virginia
Maryland	Ohio	Illinois

Depreciation accounts are mandatory in Ohio and Wisconsin, and the commission may require them in Arizona, California and New Jersey. Recent statutes provide for depreciation accounts in Idaho, Illinois, Indiana, Mississippi and Pennsylvania and Michigan.

In 18 states the consent of the commission is necessary to authorize the issue of stock and bonds.

Arizona	Michigan	Texas
California	Nebraska	Vermont
Georgia	New Hampshire	Wisconsin
Kansas	New Jersey	Illinois
Maryland	New York	Indiana
Massachusetts	Ohio	Pennsylvania

A certificate of convenience and necessity is required in 20 states before commencing operations under a franchise.

Arizona	Michigan	Idaho
California	New Hampshire	Illinois
Connecticut	New York	Indiana
Kansas	Ohio	Mississippi
Maine	South Dakota	Pennsylvania
Maryland	Vermont	West Virginia
Massachusetts	Wisconsin	

Indeterminate franchises are provided for in Massachusetts and Wisconsin and by recent legislation, according to Sharfman, in Idaho, Illinois, Indiana, Missouri, Pennsylvania and West Virginia.

Perhaps the most explicit, at least the most notable, of the public service commission laws is that of Wisconsin. The Wisconsin law provides:

Every license, permit or franchise hereafter granted to any public utility shall have the effect of an indeterminate permit, subject to the provisions of this act, and subject to the provisions that the municipality in which the major part of its property is situate may purchase the property of such utility actually used and useful for the convenience of the public at any time as provided herein, paying therefor just compensation to be determined by the commission and according to the terms and conditions fixed by the commission. Any such municipality is authorized to purchase said property, and every such public utility is required to sell such property at the value and according to the terms and conditions determined by the commission herein provided.

Utilities existing at the time of the passage of the act could, prior to July 1, 1908, surrender their franchise and receive an indeterminate franchise or permit.

The commission shall value all the property of every public utility, and may at any time on its own initiative make a revaluation of such property. The commission may fix such rates as are just and reasonable.

In the state of New York, with the exception of water works, practically all municipal utilities come under the provisions of the public service commission law.

Under this law the commission has power to fix the standard for gas and to order improvements and extensions; to prescribe the efficiency of the electric supply system, of the current supplied and the lamps furnished; to require gas to equal the standard fixed, and prescribe the maximum and minimum pressure. Charges for gas

and electricity shall not exceed those fixed by law or by the order of the commission and shall be just and reasonable. Require uniform system of keeping accounts. No gas or electrical corporation shall begin the construction of gas or electrical works without the permission and approval of the commission. The commission may grant permission and approval if such construction be found necessary or convenient for public service. No municipality shall build, maintain and operate any works or system for manufacturing and supplying gas or electricity for other than municipal purposes without a certificate of authority granted by the commission.

The commission's consent is necessary for the issue of bonds, stocks and notes.

Practically the same provisions apply to the construction of steam heating plants under a franchise or by a municipality.

Telegraph or telephone companies must have a similar certificate of necessity before constructing under a franchise.

Water works and water supplies in New York state are under the jurisdiction of the conservation commission.

All plans for a new or increased water supply must be approved by the conservation commission before works can be constructed either by a municipality or by a company under a franchise.

While franchises in Wisconsin have been made indeterminate, the length of time for which franchises may be granted in New York does not appear to have been changed.

By referring to the table it will be seen that only 15 states have placed water works under the control of their commission. Fifteen have placed practically all other utilities under commissions and in all of the 45 states the railroads are under commission control.

A study of the statutes reveals but little tendency toward shortening the duration of franchises, but on the contrary a tendency toward prolongation or, as in the case of Wisconsin, of indeterminate franchises. The indeterminate franchise has yet to win its place, although judging from recent legislation, it seems to be growing in favor. So far it is the only answer that has been made to a much vexed question. Many able lawyers have asked, "What are you going to do when your franchise expires?" And when the franchise has expired and even before, competing franchises have been granted with the result that the owners of one have purchased the other, thereby continuing with increased capitalization the previous conditions. In some cases where there was a contract for public service, as in the case of water or electric light, the municipality has

constructed works on the theory that the expiration of the contract terminated the franchise and all right to do business thereunder. Neither of these conditions is desirable. They never have resulted, and they never will result in benefit to the public at large.

With the franchises terminating at a fixed date, with no provision beyond that date, capital will grow more and more timid as that date approaches, with the consequence of a much rundown property and the poorest service that can, under the circumstances, care for the business. This has been demonstrated in many instances. To insure the proper maintenance and operation of utilities capital must be made secure not only up to but beyond any date that may be fixed.

The municipalizer will say that the remedy for all this is public ownership; and with public ownership properly acquired he is agreeing with all that has been said in this paper.

Some one has said, "Public utilities must be controlled and regulated by government, or must be left to do as they please or must be operated by the public." That they can be left to do as they please no one will contend. That they can be operated by the public is, of course, possible, but public ownership in the great majority of utilities is not here nor is it likely to be in the near future. Public ownership of water works exists in large and increasing numbers, and ownership of other utilities exists and will very likely increase. As engineers and managers we have to face both conditions. Towns that own their water works will not own any other utility; towns that own police and fire alarm systems will not own other signaling systems; towns that own the electric light plant will not own the gas plant; and towns that own the telephone system will not own the telegraph.

The question then is not how shall utilities operated under a franchise be controlled, but rather how shall utilities be controlled whether publicly or privately owned.

As a fundamental principle they should each be controlled and operated under the same rules and regulations. It will be argued that publicly owned utilities should not be operated for profit, while those privately owned are operated for that express purpose.

Every business will either show a profit or a loss and every utility, whether public or private, should be planned to show a balance on the credit side; in other words the maintenance and operation of no utility should be a charge on the general tax budget. Therefore the method of accounting should be the same in either case.

Every utility should be charged with the following:

Taxes on the same basis as other property.

Accident insurance.

Fire insurance.

All damages not covered by insurance.

Water, light, heat, telephones, etc.

Rental of offices and buildings, whether owned by the city or not, unless they are owned by the utility.

Interest on bonds, notes and other liabilities.

Legal expenses and services, even though performed by city attorney.

Engineering expenses and services, even though performed by the city's engineers.

Depreciation and sinking fund charges.

All utilities using the public streets should be charged, in addition to the repairs they are compelled to make, with an annual tax, depending on the character of the utility, to be paid into a pavement repair fund.

Every utility should be credited for every public service rendered, such as:

Fire protection.

Water for schools, fountains, street sprinkling and sewer flushing.

Electricity, gas, heat, telephones, etc.

Use of poles by other utilities.

Transportation of city employees and material not otherwise paid for.

Quoting from an article by John S. Kennedy in the *Forum*:

In some cases the affairs of the lighting plants are so interrelated with those of the water or some other department that it is impossible to determine the actual results of the operation of either department. The commission, New York state, remarks that it is a matter of supreme importance, when municipalities embark in business enterprises, that they should adopt businesslike methods. The citizens of many a village are convinced that their lighting service is cheap when, as a matter of fact, it is dear, because the lack of proper accounting system fails to reveal the actual conditions.

All plans for construction of privately owned utilities should be approved by the city's engineers or be in accordance with general specifications prepared by the city, and where approval by state officials is required the same rules should apply whether the utility is to be publicly or privately owned.

The attitude of the manager or the engineer toward his property should be the same whether publicly or privately owned.

Efficiency in management should be secured in either case, and the reward of efficiency should be freely conceded not only to the manager but also to the capital which took the risk and produced the utility. This reward should accrue to the respective owners whether they be a corporation or a municipality. The writer is aware that this latter proposition will call forth loud protestation, but he would call attention to the fact that from 60 per cent to 75 per cent of the population of every city live in rented houses and pay but little or no taxes. If a municipally owned utility is established it is the property owner who takes the risk and stands the loss. Therefore if the utility is a success the property owners should receive the benefit the same as though they were stockholders in a corporation. The proposition that municipally owned utilities should not be operated for profit is a delusion and a snare.

The proposition is boldly made that the rates for every municipally owned utility should be fixed on the basis of returning a reasonable profit. Take for example a telephone system. Fully two-thirds of the users are not taxpayers. If an unlimited suffrage compels municipal ownership, placing the risk of loss and all incidental expenses upon the realty, should not the rates be fixed so as to bring its ultimate reward in the shape of a surplus to the city treasury?

If a municipality is to engage in the business of any utility it should be required to first acquire the property of the particular utility then in existence. There may be reasonable exceptions, as in the case contemplated by the New York law, for a city to light its own streets without being required to engage in commercial lighting. Any theory of municipal ownership without acquiring the property of the utility in existence at the time must, if reasoned out to a conclusion, abrogate all right of regulation or control. On the other hand the denial of the right of government regulation will surely lead to competition by the municipality with resulting waste and disaster.

As men interested in water works you will note that in only 15 states are water works placed under the control of commissions. The reason for this is probably due to the fact that in most, if not all, states water supplies and water works are to some extent under the control of the state board of health.

In addition the franchises under which water companies operate

reserve a large measure of control to the municipalities. As a rule rates which may be charged for water as well as hydrant rental are fixed for a term of years and at the expiration of the term are subject to revision under a new contract. Some writers believe that local control is the proper method, and that commission control is wrong in principle, and the much mooted question of local self government as opposed to state control comes to the front. Here again water works afford the best field for investigation, and are the most prolific in argument for each side of the case. Local control has in many cases demonstrated its futility. Either it has been so easy that the utility company has been left to do as it pleased or it has been so severe that the utility has failed to survive. As the municipality is in fact a party to a contract it can not in fairness be left to interpret and change its terms. Resort must therefore be had to the courts or a commission, and for the present the logic of events points to the commission.

In the case of the municipally owned utility the management is frequently such that regulation by a state commission has been demonstrated to be desirable. If commission regulation is necessary for companies it is also desirable for the municipality, and all utilities whether publicly or privately owned should be subject to the same regulation.

The same system of accounts, the same principles governing charges to be made and service to be rendered, should apply to one the same as to the other.

It must not be inferred from the rapid spread of commission legislation that the panacea for all franchise troubles has been found. Franchise difficulties have always existed, from the time that Moses in anger struck the rock twice, and it is not supposable that they will at once terminate. Commissions have yet to demonstrate their practicability and usefulness; their rulings and decisions are liable to error. Much will depend upon the character and ability of the men composing the commissions. With the best of intentions equitable and just results will not always result. Their work should not be speedily approved nor too hastily denounced.

The question is one that cannot be dismissed. Public and private ownership are with us, and are bound to continue in varying proportions for years and even generations. The investments in privately owned utilities are growing to enormous figures and the question of regulation must be worked out with patience, fairness and wisdom.

THE DESIGN AND OPERATION OF INTERMITTENTLY OPERATED WATER PURIFICATION PLANTS

BY N. T. VEATCH

In our experience, in the design and operation of water filtration plants, we have learned that the plant with intermittent operation presents the most difficult problems. The practice in the past has been to depend almost entirely on the filters themselves, for the overall efficiency of the plant, and to give very little attention to the design of the settling and coagulating basins. There is little question but what the action in the basins and in the filters themselves is equally important in getting good and economical results in any filtration plant. This fact is most emphatically true of plants which are operated intermittently.

In cases where the plant is operated perhaps ten hours each day, it is difficult to get the proper conditions of water applied to the filters during the first part of each run, as the floc has almost always settled out so as to cause the first water applied to the filters to be clear, or practically so, and free from floc. The arranging of the basins so as to make it possible to handle this clear water and to prepare it for application on the filters is one of the most difficult features in the design.

It is a pretty well established fact that thorough mixing of the chemical and the raw water when first pumped into the basins is well worth the cost. There is always some question as to just how far it is wise to carry this mixing, as each water presents a separate study in itself. There are so many things that enter into the action, such as temperature, turbidity, etc., that no set length of time can be taken as the proper time for mixing. The length of time also depends on the degree of agitation. If the mixing is obtained by means of mechanically driven agitators, the time required is much less than when obtained by baffling. To meet different temperatures, and different conditions of the water, it is probably best to subject the water to at least thirty minutes of mixing when mechanically driven agitators are used, and at least an hour where

baffles are depended upon. These periods are based on the use of alum as a coagulant, and are taken from results obtained at different plants. If lime or lime and iron is used as coagulant, the length of time for mixing would vary, depending upon the results desired, such as to the degree to which it is desired to soften the water, if softening is attempted. The figures given should be considered as general only, and not be construed as the ones to use for any and all waters.

After the water has had the chemical mixed with it thoroughly, the question arises as to the best means of treating in the basins before applying to the filters. This second stage in the treatment should depend on the operation of the plant. If the operation is continuous, we find that the water should be treated in the basins in such a manner as to obtain the greatest amount of sedimentation, and at the same time carry a proper floc over onto the filter beds. In case the operation is intermittent, it is best to give the water the greatest chance for sedimentation, and not attempt to keep any floc in suspension. In this way the water at the start of any run, and at any time during the run, is as near a completely settled water as possible. This would also be the condition of a water which is subject to treatment in large settling basins, before applying to the filters.

To prepare the flocless water obtained as outlined above, for application to the filters, the best plan is to subject it to another thorough mixing. It is well to arrange this secondary mixing so that the chemical can be applied at several different points and periods before the water reaches the filters. We have found that it is convenient to be able to apply coagulant at $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ and 1 hour periods, just prior to water reaching the filters. The condition of the water, and the temperature should determine the proper place for application.

This paper is meant to deal particularly with plants where the total retention period in the basins is from 4 to 6 hours. In basins of this size it is possible to use the basins as settling and also coagulating basins combined. As indicated, previously, in this paper, if the operation is continuous, the mixing at the entrance to the basins, and proper arrangement of the basins will put the water in good condition for application. However, in intermittent operation arrangements should invariably be made for applying the chemicals just prior to passing the water onto the filters. The design of this

secondary treating basin should be given very careful study, as the chemicals should all be decomposed before reaching the filters.

The question may arise as to why it is necessary to design filter plants which operate intermittently. This is a very natural question, as it is unquestionably preferable to operate a filter plant continuously. However, the matter of cost, both first cost and that of operation, must always be considered, and especially in the smaller cities. It is necessary for the engineer to compromise his ideal installation to fit the appropriation, and give his client a plant which will operate at a minimum cost. The average city of less than 3000 people does not operate its water works plant continuously, and almost invariably the entire operation is handled by one shift, and often by one man. It generally proves to be much cheaper to pay the fixed charge on the extra investment necessary to give the city a plant that will fit in with the normal operation of the pumping plant, than to cause the city to change its plan of operation, and add one or two shifts to its operating force.

With a properly designed plant which operates intermittently, the city has a plant which will fit in with its normal operation, and as the city grows nearer the size which would require the maximum capacity of the plant, it can well afford to put on the extra help necessary to operate continuously.

It is evident that there is a great need for good engineering and careful study in the design of basins, for any plant. Some of the discredit which is given to mechanical filtration could have been avoided if proper care had been given to preparing the water for treatment on the filters.

PLUMBING CODE AND CONTROL OF PLUMBERS¹

SCOTLAND G. HIGHLAND²

The object of this paper is to show that the character of private plumbing installations and the control of plumbers are matters of vital interest to water works operators; and that the responsibility of water works officials does not cease with the delivery into the street mains under adequate pressure of a clear, germ-free, wholesome water.

The water department, knowing intimately by its own investigations and by chemical analyses the character of water supplied to consumers, is in the best possible position to give advice regarding the material suitable for supply pipes.

The amount of water to be supplied at the source is always greater than that actually needed for use. There is leakage from the service pipes, and from a considerable percentage of the plumbing fixtures in the houses, and water is allowed to run uselessly from many openings. In many cities four times as much water is supplied as is actually used. The greater part is wasted without benefit. It is mainly for this reason that the control of plumbing and plumbers by water departments is absolutely essential. The unnecessary draft of water from fixtures may be checked by universal metering and the adoption of a schedule of rates by which the payment of takers is dependent upon the amount of water passing through the meters.

A comparatively small percentage of services are metered, however, and we must deal with the problem as it exists.

The official inspection of plumbing work in cities of the United States began about the year 1881. In this year, too, the first complete plumbing code was adopted and among the cities leading in this movement were Lawrence, Massachusetts, Washington, D.C.,

¹ Read at meeting of American Water Works Association, May 9 to 15, 1915, Cincinnati, Ohio.

² Secretary and general superintendent, Clarksburg water works and sewerage board, Clarksburg, West Virginia.

New York City, Brooklyn, New York, and Chicago, Illinois. The official control of plumbing work had for some years previously been agitated and urged by health departments and by persons interested in house sanitation.

It was but natural that the first codes were enacted and enforced by health departments. Later on, this work was shifted over in some cities to the municipal building bureaus. It was claimed by some that it was more logical to include the duty of plumbing inspection with the numerous other functions of building departments, and practical advantages as regards the filing of plans in particular, were claimed for the change in departments. Still even at this day the control of plumbing in the majority of cities, which have enacted a code, is in the hands of the health commissioners or their assistants, and this is due to some extent, no doubt, to the popular belief that there is some connection between bad or imperfect plumbing and disease.

In more recent years, some of the states have enacted laws, providing for the local control of plumbing, and have issued general rules for plumbing and water supply.

Not only the large cities of the country, but many smaller cities, towns and villages have adopted plumbing codes.

The more concise, comprehensive and brief a plumbing code, the better will it fulfill its purposes. Clearness of wording is essential. Each paragraph, each rule should be definite and there should be no doubt left as to its proper meaning. No arbitrary interpretation of a rule by the plumbing inspector should be possible.

WHY ARE PLUMBING CODES REQUIRED

The writer is a firm believer in the good results which are brought about by the enactment and enforcement of plumbing codes. He has noted the vast improvements which have taken place in the past ten years in the character of the plumbing work as executed in all classes of buildings, and he can unhesitatingly state that these improvements are due, perhaps more than to any other cause, to the introduction of an official and honest supervision of plumbing by municipal authorities, or by water works departments.

In these years the art and craft of plumbing have made wonderful advances and credit for this also belongs, no doubt, to respectable and first-class plumbing firms to be found in every city or town, and

to the local and National Associations of Master Plumbers. But as in every herd of white sheep there may be found some black sheep, so there are plumbers and plumbers, and it must be said, sad though it is, that some men of the trade do not know, or if they know, do not wish to carry out a contract honestly and creditably, whenever there is a chance to "scamp the job." Therefore, to prevent imperfect work, plumbing must be inspected. The best men in the trade do not object to such inspection. It rather protects them against unscrupulous competitors. House owners, as well as tenants, should likewise welcome the introduction of a code, for it secures to them good and reliable work, and protection against leaks or other plumbing troubles.

Every plumbing code should require that all persons working at the business of plumbing, whether as a master or as a journeyman plumber, should have a certificate of competency, and should be registered.

To establish such competency and registration every code provides a board of plumbing examiners, before whom applicants should appear for examination, and who determine their qualification to engage in such business.

The board of plumbing examiners should consist of at least three, and preferably five, members. One of these should be a master plumber, another a journeyman plumber, both to be appointed for one year by the mayor, under approval of the city council. The other members should be city officials, preferably members of the water and sewer departments or the city engineer's bureau. The board should hold regular business meetings, institute the examinations, and issue licenses to the successful applicants. The secretary of the board should keep all records, books, plans, specifications and other papers, and should preferably be a municipal officer, or he may be the superintendent of the water department.

All licensed plumbers must be registered and should be required to execute a bond for the faithful performance of their work, the amount of the bond varying from \$500 to \$3000, according to the size of the city.

With the single exception of repairing leaks, all plumbing should be done only after filing plans and specifications and obtaining a proper permit from the board.

The board should appoint the plumbing inspectors. They should be selected only with reference to their fitness for the position; po-

litical favoritism should be excluded. Only by a strict adherence to this rule can an efficient corps of inspectors be maintained.

When the plumbing work in a building has been completed, tested, and inspected, the board issues to the plumber, upon his request, a certificate of inspection that the work has been properly performed as required by the provisions of the code. To make such a certificate of value to the owner of a building, it should have the signature of the plumbing inspector and of the superintendent of the water department.

WHAT CITY DEPARTMENT SHOULD CONTROL PLUMBING

The writer has already mentioned that inspection is carried out either by boards of health, or by building departments. There are, however, other municipal departments, who are interested in the plumbing code, namely: the water works department or board, the sewer department or board, the city engineer's or city manager's office, and the fire department.

There is much to be said in favor of having the plumbing controlled by a water works department, as is at present the case in Clarksburg, West Virginia. A good plumbing code is of inestimable importance to a water works department. The absolute control of plumbers is quite necessary in order that the house installation may be of a satisfactory character. This control also consists in obtaining proper reports on this installation for filing in the water department's office.

In England, for instance, the various private water companies have each its own set of very complete regulations as to the thickness, weight and quality of pipes and fittings to be used for service supply.

WHAT POINTS, BESIDES THE GENERAL ONES MENTIONED, SHOULD A CODE EMBRACE

The following are some of the essentials:

(a) It should specify the use of proper plumbing materials and require first class workmanship.

First class work implies both good materials and a careful laying out and carrying on of the work.

(b) Safety requires of the entire work freedom from leaks in supply pipes.

(c) It should strive to introduce safer, simplified and more economic plumbing systems and layouts.

(d) It should consider the possible relation between plumbing and preventable disease.

(e) It should provide proper material and sizes of service and house supply pipes, and thus insure a sufficiency of wholesome hot and cold water.

(f) It should provide proper, strong and desirable water fittings, faucets, ballcocks, tanks, etc.

(g) It should make provision against both waterhammer and noise in the house service pipes.

A good mechanic knows how to guard against waterhammer in a supply system. The entire abolishment of noises in the water pipes, boilers, and in flushing tanks is desirable, but not always easy to attain.

(h) It should guard against the freezing of water pipes and also efficiently prevent any undue waste of water.

The last two requirements are of so much importance that they will be dealt with at length further on.

In addition to the above, the plumbing code should provide that none but tappers employed by the water department should be permitted to tap any street water main.

The work of efficient municipal or private water works should not be restricted to the routine duties, which consist in providing in the city service reservoirs and in the city water mains a wholesome, germ-free supply of clear water.

Such bureaus should always have a higher aim in view, namely of having a perfect control of the supply at the house faucets, in the house storage tanks, in the basins, bathtubs or other ablution fixtures, and even of the drinking water at the consumer's table. The water delivered to the consumers should be without color, bad odor or bad taste, and free from deposits of sediment or rust in the house pipes.

Moreover, a matter of vital interest to the water department, and no less to the taxpayers, is the prevention of all unnecessary *waste of water*. This matter becomes serious, where, owing to droughts, there is a threatening shortness in the public water supply. Can it be efficiently accomplished, and if so, by what means?

Efficient water works departments have learned to cope with this question in street mains, but they should go a step further and strive

to prevent waste of water from consumers' fittings and in water takers' premises. To the average layman a slight leakage seems an unimportant matter and he is apt to overlook the fact that the effect of slight leaks, if constant, is vastly increased by the time factor. A mere dribble from a faucet, if allowed to run on unchecked for twelve months, often amounts to more than the annual tax for water. In cities and towns, where the unrestricted constant supply system is used exclusively, it is of the utmost importance that the waste be checked, however unpopular or unpleasant the application of waste-preventing measures may appear to be.

The existing water pressure has a considerable bearing upon the volume of water running to waste from defective fittings, and this is another point ignored by water takers.

While waste of water due to badly constructed apparatus, or fittings, or to defective workmanship can and is prevented by the department's plumbing supervision, where the department has the power to regulate by code the character, strength and arrangement of pipes, faucets, tanks, cisterns, fittings, boilers and plumbing fixtures, much of the waste going on in buildings is under direct control of the consumers. This refers not only to waste caused by faucets carelessly left running, but also to the waste due to *wilfully* keeping faucets open. Then we have another waste, due to running water off from the hot water faucet in cases where a circulation pipe is omitted; still another is the wilful running of faucets to get, in summer, cool water for drinking; sometimes it is caused by a cold water pipe being in contact with hot water or steam pipes or by its being carried near a kitchen or laundry ceiling, where much heat accumulates.

Consumers are likewise responsible for hidden wastes from underground service pipes which have become corroded or broken. Then there is the waste due to ordinary wear and tear, caused for instance by worn-out washers in faucets or tank ballcocks.

Fittings in private houses are much more difficult to control than those in public or semi-public buildings. Hence the water department should have proper authority to enforce a penalty for neglect of the water fittings, and also for wilful waste. In many cities and towns this is quite a customary measure of prevention.

All well-organized and efficient municipal or private water works departments issue a set of rules and regulations governing the use of water. These rules should be explicit and they must be impartially enforced. Some of the points to be covered by the rules are:

Taps and service pipes to be of size prescribed by the water department. They shall be run into the buildings only by licensed plumbers, who must file an application stating the material to be used. The connection to be inspected before being covered up to guard against poor workmanship or imperfect fittings.

All water takers are required to maintain the entire inside water system in good condition and repair. They shall also protect all pipes and fixtures from freezing.

A further precaution to prevent waste of water consists in the annual inspection of all water fittings by water department inspectors.

If space permitted, the speaker could take up numerous details regarding the water supply of buildings. Suffice it to mention but a few points.

In some English towns (like Manchester and Liverpool) all water fittings are tested and stamped by the water departments and only stamped fittings are permitted to be used. In our own country such a far-reaching control or discrimination is neither practicable nor desirable, but owners of houses should be cautioned, in their own interest, to specify or purchase only fixtures and fittings made by manufacturers of first class reputation. The difference between such fittings and cheaper ware is usually but slight, whereas the cost of removing and renewing fittings, which turn out to be defective and unsatisfactory, is considerable.

The examination, licensing and control of plumbers who wish to do any work—contract or jobbing, new work, alteration work or repairs—in connection with the water works system of a city or town, are matters of vital importance to a water department. To exercise such control without, in some cases, some friction being created is not always easy, but much can be accomplished in this direction and trouble and misunderstandings avoided by a firm and tactful conduct of the men who comprise the board.

It is decidedly to the interest of all water works plants that permission should be obtained to do work in buildings. The systematic filing of plans, of the specifications, of the record plans, showing the location of the fittings, and of diagrams, giving the number, style or type, size and material of fittings acts as a decided measure of protection to property owners. It should, therefore, be universally encouraged.

The plan which has been adopted and which is being carried out by the water works and sewerage board of Clarksburg, West Vir-

ginia, to license and control all plumbers is a thoroughly good one, and the measure is a just one, protecting as it does the water department, the conscientious and honest plumber, the realty interests and the owners and tenants of the buildings.

Some water works plants, even those where the water is purified by filtration on a large scale, fail to give entire satisfaction, because of troubles existing and persisting from the point where the water leaves the main until it reaches the consumer. Under such conditions arise numerous troubles and complaints of the water takers.

It is the business, and the duty of a progressive, broad-minded and public-spirited board to thoroughly investigate each complaint, no matter how trivial it may appear to be. Occasionally the consumer finds it necessary to complain of dirty water, and this may be caused by accumulation of deposits and rust in old, worn-out services, which cause the benefits due to the filtration plant to be lost, though there may be other causes.

The Clarksburg water works and sewerage board instituted last year a very excellent plumbing code embracing all safe and established methods of supplying water to buildings and generally all classes of work usually done by plumbers, a copy of which was furnished to every water works department in this country and Canada.

A water works department may control some of these points, and in others it can do much to retain, or regain, the confidence of the water consumer by practical advice and by intelligent and prompt action in remedying the troubles complained of.

In consequence of corrosion and leakage, cases are frequently found where the pressure on the street main as taken at the hydrant, is 100 pounds and that on the first floor of an adjacent dwelling is only 3 or 4 pounds. This condition when discovered can be corrected only by replacing the old service pipe by a new one. It can be prevented to a great extent when the service is first laid by exercising care in the selection of materials used and by procuring good workmanship.

DISCUSSION

MR. GEORGE HOUSTON: Mr. President, in cities where most of the water used is used without being metered, the advice and recommendations contained in this paper are very good and opportune. The speaker has had several years' experience in this way of furnishing water, and all of the troubles mentioned therein are very real. In order to get away from them, we adopted the general metering system, and our troubles vanished. It was found that notwithstanding all of the rules recommended in this paper, the waste of water went on just the same. Inspections following inspections, a month apart, three months apart, six months apart, and sometimes immediately after making the inspection, have found the parties using water wasting it just the same, or permitting it to run from the faucet to cool ginger ale, as has been mentioned here, in summer, or refrigerating anything that they wished to keep cool. Those in charge of the premises would promise not to do so any more, but have been found inside of twenty-four hours doing the same thing again. In order to stop water waste in that way it would be necessary to have a man on the job all the time. There is no other way to stop it. The only thing that is on the job all the time to look after waste is the water meter. If all of the cities or water companies that are troubled with the sort of complaint mentioned in this paper would adopt a general metering system they would do away with very much of their trouble in that line. We are not worried in our city to any extent about any water going to waste.

In one case where we had a consumer that we thought was using more water than he should under flat rates, we raised the assessment, and he came down and swore off a number of charges that we had made against him, and of course his oath had to be taken and a reduction made in the items charged for. Shortly after that took place the speaker prevailed on the water board to give us authority to

install a meter on the premises at the city's expense. The party was away at that time on a vacation and there was nobody around the premises but the hired help. We installed the meter at the curb line, and the first month after that his water bill which had previously been about \$8 semi-annually was \$14 and some cents for the month. That was the result of the installation of a meter. One of our leading physicians who was paying \$6 semi-annually objected to that rate, and the rate was cut down to \$4. We put a meter on his premises immediately after that, and the first month his bill was \$14.

Those are two cases, but a great number similar to them could be enumerated. The speaker is a member of our board of plumbing examiners and has been since its organization. We do not attempt to control the plumbing inside of the house, except as may be necessary from the standpoint of health, namely, with reference to sewerage plumbing. We have never attempted to have anything to say about the plumbing arrangements in the house otherwise. We put the water service in up to the curb line. The property owner through his licensed plumber takes out the permit and goes on into the house with it. We simply require that the city shall be secured against any waste or leakage that is the fault of poor plumbing in the premises by having a meter placed there by the property owner. We require plumbers to give a bond, not for the work done inside of the house, but simply to protect the city against accidents occurring through neglect to properly perform his work in the street.

MR. A. A. REIMER: The paper as a whole is an excellent one and a timely one for us to consider. The point mentioned by the last speaker is one to which we can all give a great deal of thought, namely, the necessity of the control of fixtures inside of buildings, whether that should be done through the board of health or the water department or any other special department. The speaker's own feeling in the matter is that what is generally included as the sanitary plumbing should be directly under the charge of the board of health, because that is the only point where the health factor enters in. It is best to strengthen the powers of the boards of health at all times; by all means let them have the control of the sanitary plumbing.

The rules laid down for governing plumbers as outlined in the paper are accepted as good practice and represent the requirements of examination and licensing that are pretty commonly used.

We go a little further in our own practice in requiring that every employee of a licensed plumber shall have a card of identification on his person at all times during working hours, so that we may be sure that no employees are working except under license issued by the department. We have a provision that a licensed plumber may lay service pipe from the curb line into the house; but we require that such work shall be inspected at a nominal charge by ourselves. The fact is that in all the years that we have had that provision, no licensed plumber has ever taken advantage of that permission. We do all the work from the main to the curb, and we can do it so much cheaper than the plumber, that is, cheaper to the consumer or to the owner than the plumber, that we are not troubled by ever having to inspect pipes laid in streets by licensed plumbers.

The question of leakage in house fixtures became a very serious one with us. Five years ago we made a pitometer survey of the entire city so far as the mains were concerned. After having proved definitely that the leakage in the system of mains comprising nearly 80 miles was almost negligible, we carried the inspection farther, putting the same survey on, and demonstrated absolutely that 54 per cent of the leakage which was disclosed by the pitometer survey was traceable to the house fixtures. There was a very small amount in the mains but a very much larger percentage in the house fixtures. That was the beginning of a campaign to eliminate this heavy amount of leakage, and from then on we have been metering rapidly.

Probably we have all had the experience of having a licensed plumber tell some of our customers, in case of a high bill, that it was impossible that the customer could have used that amount of water during the length of time covered by the bill; that it could not possibly pass through the meter; that the meter is wrong. Now we have not been at all bashful in our remarks about plumbers who were telling our customers that. We have simply said in so many words without mincing matters, that the plumbers did not know what they were talking about. We are gradually making the plumbers come to time on that, and we have found that they do not know very much about the quantity of water that will pass through a given size of pipe. We are getting fewer and fewer of those complaints; but there are still some plumbers who think they know more than any water department can show them in regard to the amount of water that can pass through certain pipes under certain pressure. Our men are trained to find leaks on the customer's line. When we

have trouble through the agency of the plumber telling people that there is no leak in certain premises, we go there and show them the leaks.

Now the speaker believes in the control of the plumbers, and when we find that a certain plumber has reported that there is no leak we get after that man and show him how to detect leaks in the right way; so that gradually that trouble is lessening.

Mr. Highland has stated that taps and service pipes should all be of the size prescribed by the water department. That is all right. Then he says that they shall be run into the buildings only by licensed plumbers who must file an application stating the material to be used. That provision is unwise to be worked into any plumbing code in the country. The time is coming when more and more of the departments and companies supplying water will insist on carrying supplies from the main to the meter point. If you have the meters at the curb line, that is all right and very easy; but the majority of us do not stop at the curb for metering, we go on into the house and set the meter in the house or the factory or whatever it may be. You do not find any gas company that allows a licensed plumber to lay any part of their services into the house; you do not find the electric light companies allowing some contractors to run wires up to the meter from a given point out on the feed line; and there is no difference in that regard between water, gas and electricity. We must stop this practice of allowing licensed plumbers or any contractors to carry the water from the main. By our carrying the services all the way into the house or building, whatever kind it may be, we have eliminated much of these troubles that are complained of.

The speaker wants to agree with the last speaker that his entire paper points to the need of meters; and when we have meters on 100 per cent of our total services we will find that we will need just a very few simple, effective rules to govern this whole situation and not an elaborate plumbing code.

MR. A. PRESCOTT FOLWELL: In regard to what the last speaker said as to the desirability of having the plumbing run all the way into the house by the city, the speaker understands that the code of rules suggested here would have the city run the plumbing to the curb; but thinks the idea of both speakers was to have the city run the pipes to the meter box; it happens, however, that the writer of

the paper lives in West Virginia where his meters are placed at the curb, and the last speaker lives in New Jersey where the meters are placed in the cellar. Probably they agree that the city should run the pipe to the meter wherever it is placed, and the private plumber run it from the meter to the fixtures.

MR. J. N. CHESTER: The inquiry will naturally come from private companies, as to who is going to bear the expense of running to the curb, or who is going to bear the expense of running to the cellar? If the water company lays the pipe into the cellar, who is going to stand the additional cost? The rates that must be charged either by public or private water works are in justice predicated on the investment, and if the services are run into the cellar at the expense of the plant it will mean an additional investment equal to the amount that either the city or the private company must pay in so doing.

All of these things must be taken into consideration with reference to the return the ownership gets from the investment, whether it is a private company or a municipal corporation. Another thing that has interested the speaker in this paper and in the first speaker's remarks is in regard to the amount of water that is not accounted for. There are various estimates made as to what this amounts to, and that is the thing that has interested the water consumption committee and that we endeavored to get at; the one thing regarding which we would like to see some data brought out in this discussion; that is, if it is not too far afield from the character of the paper.

MR. THEODORE A. LEISEN: There are several questions in this paper that the speaker thinks are worthy of very serious consideration. The inspection of plumbing generally would, in the opinion of the speaker, be better left to the boards of health or such other parties as may control it. Where there is a sewerage board it might be very appropriate for them to inspect all plumbing; the inspection of the water pipes unquestionably ought to come under the water board or water department, and in that inspection for the protection of the water board or department it is essential that they should determine the size of the pipe not merely from the main to the curb, but also at least through the lower portion of the house. Many superintendents have probably had experience with complaints from lack of supply in the upper stories of houses. The water department

is almost invariably blamed for not furnishing a proper supply, when in most instances the trouble is due to the fact that the pipes leading through the basement are too small to supply the number of headers running to the upper stories. That is one point that the inspection by the water department ought to cover.

We all recognize that the question of leakage would be largely controlled by the universal adoption of meters. If metering were universally adopted the waste would not be a matter of very serious consideration to the water department, unless it was deficient in the source of supply. Consumers should only use the water that they require for legitimate purposes and not allow it to run to waste.

The paper as a whole, in some points goes rather too much into detail as to the method of carrying out the suggestion and rules; that should be left in rather more general terms than it has been in this paper, because of the varying conditions in different localities.

MR. F. J. CONNOR: Will Mr. Reimer please state what kind of services they use; are they lead?

MR. A. A. REIMER: Our practice has been for small services up to 1-inch tap, to lay heavy lead pipe from the mains to the curb line, and there change to galvanized wrought iron pipe of the small sizes, and use wrought iron all the way through, the very highest grade of pipe that we can get.

MR. F. J. CONNOR: How do you handle your consumers? Do you make them put up a deposit? Have you a schedule of cost that covers the whole service from the main to the curb along the short side of the street? Or do you figure from the short or long side of the street?

MR. A. A. REIMER: East Orange is a municipal department, not a private water company, supplying the city. We have a set of rules governing all those matters. We require what might be called a "permit fee," and we make no charge for the tap or supply pipe as we call it from the main to the curb. From that point on we charge a given price per foot for the amount of pipe laid, so that a man away back from the street further than some one else pays no more to cover the additional distance. They pay a unit price per foot for the service pipe from the curb line into the building, varying with the size of the pipe.

MR. F. J. CONNOR: In other words, the service from the main to the curb is free service?

MR. A. A. REIMER: We charge the consumer nothing for that. We do not consider that the permit fee paid covers the cost of the service from the main to the curb. We charge that to capital account.

MR. F. J. CONNOR: In that case the fee that you charge practically covers the cost of the service, so that in reality it is not a free service?

MR. A. A. REIMER: We do not consider it as in any sense a permit for the service. We capitalize our connections from the main to the curb, and the fee paid is purely a license fee, that is all, and it is so regarded in our finances.

MR. F. J. CONNOR: Until about one year ago the city of Sioux Falls determined to put in the service from the main to the curb free of cost. A legislative act was passed and now we charge from the main to the curb the actual cost. Of course labor conditions and the condition of the soil and all that make a difference in the cost; but we only charge actual cost. It was found that in many cases those who ordered services put in failed to pay for the same promptly and the commissioners, finding that there was an accumulation of such accounts, that people were slow in paying for services, took up the question as to whether we would continue to put in the services in that way or whether the applicants should be required to put up a deposit at the time they made their application. Now we have a law in reference to city improvements, such as paving and other street improvements, and we are trying to get away from all of the old galvanized services. We had two water companies in Sioux Falls, and where we cut off from the old company mains and connected to the new company ones on one side of the street we would extend the service to the new main, and on the other side we would cut it and connect to the other main which, of course, crossed. We have services that are probably twenty years old. We have passed an ordinance and are trying to persuade the people to put in all lead services from the main to the curb.

We have had some trouble with complaints of short supply through the party putting on a smaller meter than the service called for; for

instance where the consumer had a $\frac{3}{4}$ -inch service he would only want to put on a $\frac{3}{4}$ -inch meter. The only remedy for that was that we would ask them to put on a larger meter when the service was of sufficient size, and convinced them that it was the meter, and not the service that was at fault. The service question is one that is confronting the speaker, who has been a plumber a good part of his life, but does not like to fall into the hands of every plumber, because a lot of them are not good lead workers. We use wiped joints, and if those joints are badly made and a leak starts, of course, the superintendent is called out of bed at night to look after the leak. You do not have any redress from some of those plumbers because they are irresponsible. The departments or water company ought to maintain and take care of the service from the main to the curb line, and that is as far as they should go; from that point you should turn it over to the property owner. Another method of putting in services is to do it by contract, and advertise for bids for the excavation and all. We charge \$3 for a tap and then insist upon our men laying the service and seeing to it that the work is thoroughly done.

MR. J. N. CHESTER: The speaker would like to ask Mr. Reimer whether all of his services are metered?

MR. A. A. REIMER: No, sir. We have about 65 per cent metered and in another two years we will probably have 100 per cent metered. In the great majority of cases we set the meter inside of the basement of the building. In a few cases we are forced to set them at the curb.

MR. H. B. MORGAN: If you set the meter in the basement why did you change from lead at the curb?

MR. A. A. REIMER: The primary reason was the element of cost; the other is the element of larger flow. The cost of 1-inch galvanized pipe, of the very highest grade is only about one-half that of lead pipe, say of $\frac{1}{2}$ -inch in diameter. In our case, we have to use AAA lead pipe on account of our pressure. If we use $\frac{1}{2}$ -inch pipe all the way through from the main to the building we are introducing a very large friction element which we can avoid by increasing the $\frac{1}{2}$ -inch lead pipe up to 1-inch galvanized iron pipe at the curb

and give the consumer a very much freer line conducing to a better flow of water.

MR. H. B. MORGAN: Do you feel that the board or company is fully protected from leaks when using galvanized iron pipe?

MR. A. A. REIMER: We have been in very close touch with the wrought iron pipe question owing to the fact that the speaker has been on the committee that has been taking up the question of wrought iron pipe, and feels that he is in a pretty safe position in specifying wrought iron pipe, since he knows what he wants and knows how to get it too. Specify nothing but strictly genuine wrought iron pipe; it is to be had if you want to get it.

MR. H. B. MORGAN: Those of us who are not so well versed in pipes as the gentleman who just spoke, perhaps might be fooled as to whether the pipe was galvanized iron or galvanized steel. There are perhaps not a dozen men in this hall who can tell the difference between the two. The speaker knows he could not, but he does not claim to be an expert.

The speaker cannot see any very good logic in requiring lead pipe from the main to the curb and allowing wrought iron pipe to be installed from the curb to the building where the meter is placed in the cellar. If the meters were placed at the curb it would make very little difference to the water company or the water board whether the pipe from the curb to the building was iron or lead, for the meter would register the leaks. Our company requires that all pipes of 1 inch and less, where laid under the ground or floor of a building, shall be extra strong lead pipe. We also require plumbers to leave the ditch open so that we may inspect the pipe after it is laid. This is done for the protection of the consumer, as well as the company.

Recently a meter was set at the curb on a service supplying a building with a single fixture, a kitchen sink. In one month 300,000 gallons of water passed through that meter. At one time the supply of water for this premises was taken from a hydrant located in the front yard. Afterwards the hydrant was removed and the pipe extended to the kitchen sink in the building. The pipe from the curb to the hydrant was laid many years ago and was iron. We did not require them to replace the iron pipe with lead, but we did

require lead pipe from the location of the hydrant into the building. The leak that caused 300,000 gallons to pass through the meter in one month was located in the iron pipe, which was full of holes. This pipe had probably been leaking for a good many years and the leak was only detected by the placing of the meter.

It would seem that this convention should understand these things thoroughly, and should realize that it is our duty to provide and use the best material obtainable for service pipes, not only for our own protection from waste of water through leakage, but also for the protection of the consumer. In fact, our State Utilities Commission insists that when meters are set on services a thorough test shall be made to see if there are any leaks in the consumer's pipes, and if leaks are found, to notify the owner to make repairs.

We might go on at length with this discussion, and afterwards go home and handle this subject as we think best and to our own benefit. The speaker quite agrees with some of the gentlemen here that plumbers are the poorest lot of mechanics that we have to deal with, but we are up against it, and will have to handle them as best we can; but we should insist on the one point, that all ditches where plumbers are laying service pipes should be left open for inspection before filling in. In some cases plumbers neglect to do this. We then require them before the water is turned on to uncover the pipe.

MR. J. M. DIVEN: One reason for using a better quality of pipe to the curb line is to avoid tearing up the streets to make repairs.

MR. THEODORE A. LEISEN: Mr. Morgan struck one very important keynote when he referred to the fact that any inspection or any action by any of the departments should undertake to carry with it just as full responsibility of protecting the owner of the premises as it does of protecting the interests of the department represented.

There is no question but that it is desirable for the water department to run all services at least to the curb, and preferably to what is commonly designated as the property or building line. Whether that is done at the expense of the consumer or not, is purely a question of how the revenues are derived. In the final analysis the consumer must pay for that pipe either directly or indirectly; it is just the difference between direct or indirect taxation as applied to general improvement.

If a certain class of pipe is required from the main to the curb the same quality should be continued as far as the department's responsibility goes in the laying of that pipe, and the very small difference in expense would hardly warrant using inferior grades of material, if it is inferior. If it is not inferior, then there is no reason for discrimination between either one side or the other of the curb, the responsibility will have to be assumed by the water department. When the house is built on the property line as is usually the case in the business section, going a foot or two further in to make the connection through the wall to connect with the meter is a small matter; but if the house or store sits back 25 or 30 feet from the street line it necessitates carrying the pipe through a larger amount of private property, and then there might be a serious question brought up as to whether the department should do that or leave it to the owner.

On the question of paying for the services, the speaker might refer to an experience in Louisville, Kentucky, where for a long number of years the services were put into the property line from the main free of cost. Later, after several years, that method was changed and the consumer was charged with the actual cost of the services in each instance. There were some objections raised at first, but owing to the absolute confidence in the board of water commissioners at that time the matter passed over and the public was very well satisfied. Later, after that condition had been in force for about four years, they went back to the old method of putting the services in free. The cost of a $\frac{3}{4}$ -inch service in Louisville covering a period of years and taking an average length of from 30 to 32 feet on a $\frac{3}{4}$ -inch lead service, was less than \$12. It averaged that for several years—between \$11 and \$12, including the corporation cock, the stop-box at the curb and the lead pipe running from the stop-box into the building line; so that the conditions there would be probably more or less the same as they are in any section of the country where they do not have to blast through rock. With that cost the speaker can hardly see why there would be any excuse for considering any other class of material so far as the expense item is concerned.

A MEMBER: Does \$12 cover the cost of replacing the pavement?

MR. THEODORE A. LEISEN: Yes, on an average, that covers everything.

A MEMBER: Is the committee that is investigating wrought iron pipe also investigating the relative desirability of wrought iron pipe as compared with lead pipe?

MR. A. A. REIMER: Our committee has that matter under investigation at the present time. We have been working on that for the past two years.

MR. H. C. HODGKINS: The speaker will look for the results of the committee's work with a great deal of interest. He thinks there is a very widespread mistaken idea as to the relative desirability of the two kinds of pipe. Certainly the information should be very valuable to this Association as superintendents.

MR. B. F. SOUDER: Our department puts in the services and controls the services from the main to the curb. The price of the services is governed according to the width of the street; for instance, the property-owner comes to the water department to order a service, we ask him what size service he wants. By the way, we use tin-lined iron pipe from the main to the curb with the corporation and the tail piece as we call it.

Our charges for street services are as follows:

WATER DEPARTMENT OF ATLANTIC CITY

Price List of Street Services
To take effect February 16, 1909

DIAMETER OF PIPE	$\frac{1}{2}$ -INCH	1-INCH	1 $\frac{1}{2}$ -INCH	1 $\frac{1}{2}$ -INCH	2-INCH
Streets and alleys 25 feet wide and less.....	\$11.00	\$14.00	\$23.00	\$29.00	\$40.00
Avenues 30 feet wide.....	13.50	18.25	25.00	32.50	46.00
Avenues 36 feet wide.....	14.50	19.75	27.00	36.00	50.00
Avenues 50 feet wide.....	17.00	24.00	33.00	43.00	59.00
Avenues 75 feet wide.....	22.00	30.00	40.00	55.00	75.00

Add to above price \$2.00 for bitulithic or asphalt streets.

Highway department charge for opening streets in addition to above schedule:

Gravel.....	\$1.10	Asphalt between Florida and Albany.....	\$23.33
Macadam.....	4.90	Bitulithic—Atlantic Ave.....	25.00
Brick.....	19.00	Bitulithic—Virginia, South Carolina, Ocean and Tennessee.....	32.90
Telford.....	16.80	Wooden block.....	33.90
Asphalt between Main and New Jersey.....	23.33		
Asphalt between New Jersey and Florida.....	15.90		

When they come to the office to order a connection with the main and state the location, we instruct the applicant that he must go into the highway department, take out a permit to open the street and bring that permit back to the water office. We then issue the permit, they paying cash for the service in advance. If the streets are paved with bitulithic, asphalt, brick, macadam or gravel, etc., the cost of opening the street varies; for a gravel street they would have to pay \$1.10 to the highway department for a permit to open the street; for macadam, \$4.90; for brick, \$19; asphalt, between Maine and New Jersey Avenue, \$23.33; asphalt, between New Jersey Avenue and Florida Avenue, \$15.50; bitulithic on Atlantic Avenue, \$25; on Virginia Avenue, South Carolina Avenue, Ocean Avenue, and Tennessee Avenue, \$32.90; wooden block, \$33.90.

If it is a bitulithic paved street it is harder to open and an extra cost of \$2 is added when they pay for the permit for the service. We maintain that service; we don't aim to make anything, but we try not to lose on it.

We use tin-lined pipe that costs us in Atlantic City 40 cents a foot for $\frac{3}{4}$ -inch pipe, and is said to have life everlasting; so that when they come to order a service and say, "Well, it seems to me that is a pretty stiff price," we say to them, "It has life everlasting, and never has to be renewed."

The size of taps is governed according to the size of the building. If it is a large hotel and they want larger than 2-inch we give 4-inch; if they want 3-inch we give them 4-inch instead of 3-inch, because we can put in a 4-inch cast iron service cheaper than we can put in a 3-inch wrought iron service. We don't recommend 3-inch wrought iron for hotels, but we give them cast iron. We control and own the meters. We buy the meters and set them at the curb. The meters are invariably all at the curb. We set them there and the plumber takes the service from there.

We compel the plumbers to take out a license. After the work is completed and they are ready to have the water turned on we send an inspector there who inspects the whole building and sees that the work is all right and everything is tight. Then we turn the water on if they have made an application for water. They pay in advance the minimum rate which is governed according to the number of rooms and fixtures there are in the house.

Small meters are read quarterly; the large meters we read monthly; so that we keep in touch with them. When the meters are read the

book is left in the office and is gone over there. If we find that they have used more water during the month than they are allowed by the minimum rate we immediately send them a postal card notifying them that their minimum has been exceeded; that they have used a certain number of cubic feet equivalent to so much money. We send the inspector there, and after we get his report we notify them what the trouble is, and the next month if the inspector goes there and finds that they have not attended to it in accordance with the notice, we shut the water off until they do attend to it. Our minimum rates are as follows:

ATLANTIC CITY WATER DEPARTMENT

Information for Water Consumers

	<i>Cub. feet</i>	<i>Gals.</i>
Minimum Rate \$ 5.00 entitles you to.....	5,555	41,667
10.00	11,111	83,000
13.00	14,444	108,333
18.00	20,000	150,000
25.00	27,777	208,333
35.00	38,888	291,667
50.00	55,555	416,667
75.00	83,333	625,000

MR. GEORGE HOUSTON: Realizing that we are taking up a lot of time with this discussion, the speaker did not divert any more than necessary or attempt to cover any more ground, but is reminded of a story, in listening to these talks, of the foolish child that stuck its finger on the hot stove and then yelled for somebody to assist it out of its trouble by putting more wood into the fire. It is astonishing how men that have been engaged on water works matters as long as some of these gentlemen have will keep on inviting trouble into their own camp. What excuse is there for water works men to assume that a private or a municipally owned company should take on the responsibility for putting the water plumbing into a man's house. There is no excuse for it on earth. If you assume the control of the plumbing inside of a man's property, and go there and inspect it after it is installed and pronounce it O.K., the next time he comes in to pay a bill that is \$5 or \$6 higher than it ought to be, on account of leaking pipes or fixtures, what are you going to say? Can you tell that man conscientiously that he has to pay the bill? No. That is the experience of every water works man, no matter whether he is col-

lecting for a private company or a municipal plant. Why, that man will at once tell you, "You have had the plumbing inspected, and you ought to know, or see to it that it is all right." Why should we make it our business to inspect house plumbing. We told a man that came in to pay a bill of \$52 for one quarter, when his average bill was \$3.75, that we had nothing to do with the plumbing. If you take on responsibility for the plumbing you are holding yourselves responsible for the shortcomings of any job, and you cannot get away from it. Why do you want to invite that trouble upon yourselves all the time? Go home and think it over, and you who have not had experience in that line, think it over good and strong!

MR. W. F. WILCOX: The speaker had occasion about a year ago to try to tabulate the amount of water that could be accounted for by different plants, and arrived at the conclusion that the average amount of water accounted for by different plants was somewhere in the neighborhood of 75 per cent; that 80 per cent was high, and 85 per cent was excellent; that there were very few plants according to their statements that had accounted for 85 per cent of their water. Below 75 per cent would indicate bad management. The report obtained and the result of all the compilations secured showed the above facts.

Somebody here asked the question about buying pure wrought iron pipe. The speaker seriously doubts if there is enough pure wrought iron pipe made in the United States to supply the demand. The pipe people are spending a great deal of money in maintaining a large laboratory to test their pipe, and they are sending out men to investigate any pipe which fails, because they want that information. It would be wise for every man to determine, taking into account his own conditions, whether he can use lead pipe, lead lined pipe, or wrought iron pipe. It is doubtful whether your committee will get enough reliable data to lay down any hard and fast rule that is going to do for any considerable number of plants.

MR. FRANCIS C. HERSEY: From the last speaker's statements, the percentage of unaccounted-for water was leakage in the mains and perhaps meter under-registration. Is that correct?

MR. W. F. WILCOX: Yes.

MR. GEORGE HORNUNG: Some forty years ago the speaker became manager of a water works, and the question of accounting for the water pumped and consumed came before him. To do this properly, the water pumped was measured, so as to be able to report not only the actual consumption of water by the city, but also to keep informed on the efficiency of the pumping plant. In this case there was a divided reservoir; in one of the basins was constructed a weir, and the caretaker of the reservoir was taught to use the hook gauge, and when he became proficient in this, weir readings were taken daily between the hours of twelve and one o'clock. At the same time and hour, counter readings were taken of the revolutions made by the engine. These weir readings and revolutions of engines were sent to the speaker daily, and the computed results from this data showed that the per capita consumption did not exceed 30 gallons per day.

About twelve years ago the speaker again became the manager of this plant, and upon that occasion the city was about to issue bonds for the purchase of additional pumping machinery. From a preliminary investigation of the machinery it was found to be large enough, if put in thorough repair, to amply supply the city for years to come. For ascertaining the amount of water the engines were pumping in the condition they were in, a Venturi meter was placed in the pipe through which the engines were pumping, and the results obtained indicated that the loss of pump action or slippage was 50 per cent. After the repairs were made meter measurements of the water discharged by the pumps were again taken, which gave a loss of pump action of a fraction less than 3 per cent.

The water consumption per capita, as usually published in the annual water works reports, is generally based on plunger displacement of the pump, with a small correction for pump slippage, which cannot be relied upon, for reasons as heretofore stated, unless the water delivered by the pumps is actually measured. As an illustration of the unreliability of the method of reporting the water delivered by a pumping engine when based on plunger displacement, the following instance may be cited: in the investigation of a large pumping station an engine with a rated capacity of 24,000,000 gallons per day, was found operating for two weeks without pumping any water; or in other words the slippage or loss of pump action in this case, was equal to 100 per cent; but with all that, the daily read-

ing of the counter on the engine, and its computed plunger displacement, was sent by the chief operating engineer to the office of the superintendent of that water works, and there accepted without being questioned in entering it up with the remaining engines in operation as water pumped and consumed. The discharge pipe or force main of this engine approached the reservoir on a uniform ascending grade, and finally curved vertically, with its end flush with the bottom of a large flume constructed of masonry alongside of the reservoir, through which the water was led to the latter. Into this flume six other engines were delivering their water at one time; hence the failure of this particular engine went undiscovered until all of the others were shut down and this one operated by itself.

MR. WIRT J. WILLS: Mr. President and gentlemen, inasmuch as this discussion has covered almost the entire life history of every other water department it had better get a look-in now relating to the conditions in Memphis, which has been a municipally owned plant. The connection from the main to the curb is paid for by the city and put in by the water department. The city has a plumbing inspector who inspects the plumbing inside of the building.

MR. W. F. WILCOX: Mr. Hornung took up the question of pump slippage as affecting unaccounted-for water. The speaker cannot see how anybody would carry pump slippage over into that account. Any man with a very rough apparatus can find out what his pump slippage is.

THE SECTIONS

NEW YORK

The first 1915-16 meeting of the New York Section was held at the Manhattan Hotel, October 20, 1915, Mr. Robert E. Milligan presiding. Eighty members and guests were registered. Luncheon was served, after which Mr. Carl P. Birkenbine read a paper "Variations in Precipitation as Affecting Water Works Engineering," illustrated by lantern slides. The paper was discussed by Messrs. A. J. Provost (using lantern slides), John C. Trautwine, Jr., William W. Brush, Sidney K. Clapp and Francis F. Longley. Mr. J. Waldo Smith presented some lantern slides of the Los Angeles Aqueduct, accompanying them with a running talk.

The New York Section will have two more meetings during the winter 1915-16, the third Wednesdays in December (15th) and February (16th).

ILLINOIS

The fall meeting of the Illinois Section was held at Hotel Sherman, Chicago, October 19, 1915. Luncheon was served at the College Inn, after which automobiles, furnished by the Chicago members of the Section, and representatives of supply houses, took the members to the new Municipal pier, the Lakeview pumping station, the Wilson Avenue tunnel on the lake front, the site of the new pumping station at Mayfair, and the new Municipal shops. Dinner was served at the Hotel Sherman, after which the following papers, illustrated by lantern slides, were presented:

"Design and Construction of the New City Intake," by Mr. John Ericson; "Water Softening Practice," by Mr. Samuel A. Greeley.

Mr. W. J. Spaulding also presented a paper "Saving by Preventing Water Waste."

A letter was received from the American Society of Civil Engineers, asking for the coöperation of the Section in bringing about unity of action where the advancement of engineers interested may be jointly

undertaken. The chairman was authorized to appoint a committee to investigate and report.

The next meeting will be held, jointly with the Illinois Society of Engineers and Surveyors, at the University of Illinois, Urbana, January 25 to 27, 1916. Papers of special interest to water works men will be given on January 25, and the business of the section will be transacted on that date. On the 26th and 27th joint sessions will be held. All members of the American Water Works Association are invited to attend.

CENTRAL STATES

The first meeting of the Central States Section was held at the Chittenden Hotel, Columbus, Ohio, October 20 and 21, 1915. Papers were read as follows:

"Sources of Water Pollution," by Mr. John W. Hill; "The Development of Rapid Sand Filters in Ohio," by Mr. Phillip Burgess, and a paper by Mr. McCullom (title not reported).

The following officers of the section were elected:

Chairman, Mr. Jerry O'Shaughnessy, Columbus, Ohio.

Vice-Chairman, Mr. Elroy Tobias, Hastings, Mich.

Treasurer, Mr. A. W. Inman, Massillon, Ohio.

Directors, Mr. C. W. Wiles, Delaware, Ohio; Mr. Charles Londick, Three Rivers, Mich.; Mr. H. H. Frost, Akron, Ohio.

IOWA

A meeting of the Iowa Section has been called for December 3 and 4, 1915, but no program or particulars have been received. At this meeting the organization of this Section will be perfected and officers elected.

PHILADELPHIA

Members of the Association residing in Eastern Pennsylvania, New Jersey south of and including Trenton, Delaware and Maryland, have petitioned for the formation of a section, and the Executive Committee has granted the request. No meeting has as yet been held for organization.

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PLUMBING CODE AND CONTROL OF PLUMBERS

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